Public Health Assessment for

JET PROPULSION LABORATORY
PASADENA, LOS ANGELES COUNTY, CALIFORNIA
CERCLIS NO. CA9800013030
AUGUST 4, 1998

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

SEPTEMBER 20, 1998

PUBLIC HEALTH ASSESSMENT

NATIONAL AERONAUTIC AND SPACE ADMINISTRATION

JET PROPULSION LABORATORY

PASADENA, LOS ANGELES COUNTY, CALIFORNIA

CERCLIS NO. CA9800013030

Prepared by:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Agency for Toxic Substances and Disease Registry .... Claire V. Broome, M.D., Acting Administrator
Barry L. Johnson, Ph.D., Assistant Administrator

Division of Health Assessment and Consultation .... Robert C. Williams, P.E., DEE, Director

Community Involvement Branch .... Germano E. Pereira, Chief

Exposure Investigations and Consultation Branch................................ John E. Abraham, Ph.D, Chief

Federal Facilities Assessment Branch... Sandra G. Isaacs, Chief

Program Evaluation, Records, and Information .... Max M. Howie, Jr., M.S., Chief

Superfund Site Assessment Branch.................................... Sharon Williams-Fleetwood, Ph.D., Chief

Use of trade names is for identification only and does not constitute endorsement by the Public Health Service or the U.S. Department of Health and Human Services.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Attn: Chief, Program Evaluation, Records, and Information Services Branch, E-56
1600 Clifton Road, N.E., Atlanta, Georgia 30333

Additional copies of this report are available from:
National Technical Information Service, Springfield, Virginia
(703) 487-4650

You May Contact ATSDR TOLL FREE at
1-800-447-1544
or
Visit our Home Page at: http://atsdr1.atsdr.cdc.gov:8080/

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E-56), Atlanta, GA 30333.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
BTEX	benzene, toluene, ethylbenzene, and total xylenes
CDHS	California Department of Health Services
CREG	Cancer Risk Evaluation Guide
CTC	carbon tetrachloride
cy	cubic yard
CV	comparison value
DCA	1,1- or 1,2-dichloroethane
DCE	1,2-dichloroethene
EMEG	ATSDR's environmental media evaluation guide
EPA	United States Environmental Protection Agency
ESI	expanded site investigation
FS	feasibility study
JPL	Jet Propulsion Laboratory
MCL	EPA's maximum contaminant level
MDWC	Metropolitan District Water Commission of Southern California
NASA	National Aeronautics and Space Administration
ND	nondetectable
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
OU	operable unit
PA	preliminary assessment
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
PHA	Public Health Assessment
PHAP	public health action plan
ppb	parts per billion
ppm	parts per million
RfD	reference dose
RMEG	reference dose media evaluation guide
RI	remedial investigation
SVOC	semivolatile organic compound
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TSH	thyroid stimulating hormone
VOC	volatile organic compound

SUMMARY

The National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) is located in Pasadena, California, northeast of Interstate 210. Established before World War II, the facility has been under the jurisdiction of NASA since 1958. Activities at JPL currently focus on automated exploration of the solar system and deep space. Under a contract with NASA, the California Institute of Technology runs JPL and maintains the facility.

Areas of concern at JPL are divided into three operable units (OUs):

- *OU 1: On-site groundwater.* This OU addresses contaminated groundwater directly beneath the JPL site and the adjacent Arroyo Seco.
- *OU 2: On-site contamination sources.* This OU encompasses all potential contaminant sources in soil at JPL. The majority of these sources are seepage pits where JPL allegedly disposed of liquid hazardous wastes before installing a sewer system in the early 1960s. Other source areas include waste pits, stormwater discharge points, and chemical spill areas.
- *OU 3: Off-site groundwater.* This OU addresses any potential groundwater contamination detected in nearby communities east of the Arroyo Seco.

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted site visits in 1997. During these visits, ATSDR identified two pathways where people could potentially be exposed to site-related contaminants: 1) exposure to contaminated groundwater and 2) exposure to contaminated soil. ATSDR also identified the following primary community concerns: 1) future groundwater and drinking water quality and 2) increased incidence of Hodgkin's disease. The

evaluation of these potential pathways and community concerns is the focus of this Public Health Assessment.

Groundwater

ATSDR reviewed and evaluated available on- and off-site groundwater data. Potential contaminants of concern include volatile organic compounds (VOCs) and perchlorate (a chemical component of solid rocket fuel). On-site groundwater has not affected the health of JPL employees because it has never been used as a source of drinking water.

VOC-contaminated off-site groundwater does not present a past, present, or future public health hazard because water purveyors, under the supervision of the California Department of Health Services (CDHS), have regularly monitored drinking water wells and taken steps (e.g., water blending, water treatment, or well closure) to ensure that the water distributed to consumers is safe. These actions will continue to prevent exposures to contaminated groundwater in the future.

Perchlorate contamination was detected in off-site groundwater at levels that would not be expected to cause adverse health effects. As with the VOCs, current sampling and blending procedures used by the drinking water purveyors will prevent harmful exposures to perchlorate in groundwater. If perchlorate levels continue to rise, however, these water purveyors could be forced to close down drinking water wells and buy imported water instead. Insufficient data are available to estimate exposure to perchlorate in groundwater before 1997 and to reach a definite conclusion about possible adverse health effects. However, based on the 1997 perchlorate data, as well as information on groundwater flow and the migration of other contaminants, it is unlikely that past exposure to perchlorate in groundwater posed a public health hazard.

Soil

Exposure to contaminated soils associated with the JPL site and in the Arroyo Seco near the JPL boundary are unlikely to cause either short-term or long-term adverse health effects to workers and the public due to low contaminant levels, depth of burial, and/or infrequent or unlikely exposure. VOC vapors were detected in relatively shallow soil in the area of Building 107, but indoor air quality sampling in this building detected no VOC vapors.

Based on a review of the available information on groundwater and soil contamination, ATSDR concludes that JPL should be assigned to the *Indeterminate Public Health Hazard* category.

BACKGROUND

Site Description and History

The National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) is located in Pasadena, California, northeast of Interstate 210. JPL consists of approximately 155 buildings on a 176-acre campus situated on a foothill ridge of the San Gabriel Mountains (see Figure 1). The facility is located within the boundaries of the cities of Pasadena and La Cañada-Flintridge; residential areas of these cities and the community of Altadena are within 1 to 3 miles of JPL. JPL is bordered to the north by the Angeles National Forest; to the east by the Arroyo Seco (an intermittent stream bed) and spreading grounds (a series of man-made basins used to percolate runoff water to replenish the aquifer); to the west by a residential neighborhood; and to the south by an equestrian club, a fire station, a U.S. Forest Service Ranger Station, and the Oak Grove Park. Also located south of the facility are several schools and the Devil's Gate Reservoir.

In 1936, a group of researchers began experimenting with rocket fuels in Pasadena's Arroyo Seco. The group was soon enlisted to conduct research for the U.S. military, and in 1945 the group was designated the Jet Propulsion Laboratory, under the jurisdiction of the U.S. Army. In 1958, the facility was transferred to NASA and assigned a mission of research and development in aeronautics, space technology, and space transportation (JPL, 1991b).

The California Institute of Technology is currently under contract with NASA to perform research and development at JPL, as well as to manage the facilities. NASA maintains a presence at the facility in a supervisory role only. Primary activities at JPL currently include automated exploration of the solar system and deep space (including the Mars Pathfinder mission) and design and operation of the Deep Space Network that tracks spacecraft.

In performing these tasks, support facilities and research and development laboratories at JPL have used a variety of chemicals including chlorinated solvents, solid rocket fuel propellants, cooling tower chemicals, sulfuric acid, Freon, mercury, and various laboratory chemicals. From 1945 to 1960, JPL may have disposed of liquid and solid wastes, including chemical wastes, in over 40 seepage pits and waste pits on the facility grounds (JPL, 1991a). It is believed that the seepage pits were backfilled between 1960 and 1963, when JPL installed a sewer system (Ebasco, 1990a, 1993). Since there is very little undeveloped land on the facility grounds, these disposal areas are now located under buildings, retaining walls, parking lots, roads, and flower planters. JPL now transports all of its hazardous wastes off site for destruction, disposal, or recycling.

Remedial and Regulatory History

In 1980, the city of Pasadena detected volatile organic compounds (VOCs)—carbon tetrachloride (CTC) and trichloroethylene (TCE)—in municipal wells located in and east of the Arroyo Seco spreading grounds southeast of JPL. VOCs were also detected at around the same time in two drinking water wells operated by the Lincoln Avenue Water Company, which primarily supplies the community of Altadena. Although the detected VOC concentrations initially did not exceed California drinking water standards, the contaminant levels gradually rose, and California Department of Health Services (CDHS) subsequently lowered its standards, so that the contamination in these wells was eventually above state standards (JPL, 1997a, 1994c). These elevated contaminant concentrations forced the closure of two Pasadena municipal wells in 1985, followed by closure of the two Lincoln Avenue wells in 1987, and finally the remaining two Pasadena wells in 1989 (JPL, 1994c).

Because JPL is the major industrial establishment near these wells, it was suspected to be the source of the groundwater contamination. JPL and the city of Pasadena conducted preliminary assessment (PA) activities in 1982, 1984, 1986, and 1987 to identify the source(s) of contamination (JPL, 1991a).

In 1990, NASA funded the construction of a water treatment plant for the four contaminated Pasadena municipal wells. This allowed the city of Pasadena to resume production of drinking water from these wells. Also in 1990, JPL removed a suspected contaminant source area consisting of a storm drain and 160 cubic yards (cy) of soil and sludge (JPL, 1994c). The Lincoln Avenue Water Company built a water treatment system in 1992 which allowed them to reopen the two closed drinking water wells.

In 1992, following an expanded site inspection (ESI) that identified CTC, tetrachloroethylene (PCE), TCE, and 1,1-dichloroethane (DCA) above drinking water standards in on-site groundwater (Ebasco, 1990a), JPL was placed on the U.S. Environmental Protection Agency's (EPA's) National Priority List (NPL).

In December 1992, EPA, the state of California, and JPL negotiated a Federal Facilities Agreement specifying how investigation and cleanup work at the site would be conducted.

During the site investigation process, JPL was divided into three operable units (OUs) to facilitate characterization of the sources, nature, and extent of contamination at and around the installation and to enable the proper design of cleanup measures (the OUs are shown in Figure 2). At each OU, JPL is now conducting both a remedial investigation (RI) to identify and characterize the contamination and a feasibility study (FS) to determine the best methods of remediation.

- *OU 1: On-site groundwater.* This OU addresses contaminated groundwater directly beneath the JPL site and the adjacent Arroyo Seco. RI/FS activities have included installation of 19 groundwater monitoring wells on JPL grounds and in the arroyo. By periodically monitoring the presence of contaminants in these wells, and performing computer modeling of groundwater movement, investigators will determine possible remedial actions. Current information about on-site groundwater contamination is summarized in Table 1.

- *OU 2: On-site contamination sources.* This OU encompasses all potential contaminant sources in soil at JPL. The majority of these sources are seepage pits where JPL allegedly disposed of liquid hazardous wastes before installing a sewer system in the early 1960s (connected to the Pasadena/Los Angeles sanitary sewer system). Other source areas include waste pits, stormwater discharge points, and chemical spill areas. A conceptual cross section of JPL showing potential contamination sources is presented in Figure 3. Figure 4 is a three-dimensional model of JPL which shows the relationship of the contamination sources to nearby city of Pasadena drinking water wells. RI/FS activities at OU 2 have included soil-vapor probes, soil sampling, and/or installation of soil-vapor wells at suspected source areas. These activities will help investigators characterize soil contamination and evaluate clean-up strategies. Current information about these on-site contamination sources is summarized in Table 1.

- *OU 3: Off-site groundwater.* This OU addresses any potential groundwater contamination detected in communities east of the Arroyo Seco. RI/FS activities have included installation of five groundwater monitoring wells in nearby Altadena and Pasadena. Monitoring these wells will help indicate whether contaminants have moved off site and determine the direction of movement and extent of contamination. Current information about all drinking water wells in the vicinity of JPL is summarized in Table 1.

A single RI report for OUs 1 and 3 is scheduled to be completed in March 1999. An FS report for OUs 1 and 3 is also scheduled for completion in March 1999. JPL is currently considering an interim removal action for OU 2 to begin removing VOC vapors from soil at JPL (JPL 1997a, 1998).

In the summer of 1997, perchlorate, a chemical used in solid rocket fuel, was detected in monitoring wells at JPL and in municipal wells near JPL. Perchlorate has become a contaminant of concern only recently, because until 1997 there was no laboratory test to detect low levels of perchlorate in water. Although there is a good deal of information about the health effects from short-term exposure to perchlorate, relatively little is currently known about the effects from long-term exposure (CDHS, 1997). Numerous studies of both the toxicological effects of perchlorate and methods to remove perchlorate from water are currently underway. Until more information about perchlorate becomes available, the Agency for Toxic Substances and Disease Registry (ATSDR) is unable to fully evaluate any potential public health hazards related to perchlorate at JPL. ATSDR will evaluate all new data on perchlorate as they become available, and will use any and all new information to further assess the perchlorate contamination at JPL. A summary of current information about perchlorate and its occurrence at JPL is presented in Appendix B.

ATSDR conducted initial site visits at JPL on August 12 and August 20, 1997, to meet with JPL environmental personnel and state public health and environmental officials and to gather information pertinent to the preparation of a public health assessment (PHA) for this site. On December 2 and 3, 1997, ATSDR conducted another site visit to collect further information for the PHA and held a number of public availability sessions with community members to hear community concerns regarding the environmental conditions in and around JPL.

Demographics

JPL has a work force of approximately 8,000 people (6,000 employees and 2,000 contractors). Approximately 30 percent of JPL employees come from Pasadena, 7 percent from Altadena, and 7 percent from La Cañada- Flintridge (JPL, 1994c). There are no residents on the JPL property.

Population data, housing data, and a census tract map of the JPL area are presented in Appendix C. The total population residing in the vicinity of JPL includes:

- 9,500 people within 1 mile of the site
- 17,000 people within 2 miles of the site
- 20,000 people within 3 miles of the site

The city of Pasadena borders JPL to the south and southeast and has primarily residential, office, retail, and service areas. From 1980 to 1990, the population of Pasadena grew 9.7 percent to 131,591 (JPL, 1994c).

Altadena borders JPL to the east. Altadena has residential as well as office, retail, and service areas, but Altadena residents are generally employed outside their home community. From 1980 to 1990, Altadena's population rose 3.9 percent to 42,658 (JPL, 1994c).

Bordering JPL to the west is La Cañada-Flintridge. Most residents commute outside of La Cañada-Flintridge to work. From 1980 to 1990, the population declined 2.9 percent to 19,578 (JPL, 1994c).

Land Use and Natural Resources

JPL is an active research and development facility that performs light industrial activities. The perimeter of the facility is surrounded by an 8-foot high chain link fence with motion detectors; access to the facility is controlled at all times (JPL, 1994c). Adjacent areas to the east and west of the facility, except for Arroyo Seco, are primarily residential; the adjacent Arroyo Seco area to the east and south includes a reservoir, park, ranger station, fire station, and equestrian club; directly north of the facility are the San Gabriel Mountains and the Angeles National Forest.

Employees at JPL receive public drinking water from the city of Pasadena. Pasadena pumps groundwater from the Raymond Basin from wells to reservoirs, where it blends this "raw" water with imported water from the Metropolitan District Water Commission of Southern California (MDWC) before distributing the blended (or "finished") water to its customers. On average, about half of the city of Pasadena's water supply comes from the MDWC. The MDWC's imported supplies are from northern California via the California Water Project and its supply from the Colorado River (Raymond Basin, 1998b). Groundwater beneath JPL has never been pumped for use as drinking water (JPL, 1997e).

JPL is situated on an alluvial fan formed by sediments that washed down from higher ground in the San Gabriel Mountains. The facility is located in the Monk Hill Sub-Basin of the Raymond Basin, an aquifer covering approximately 40 square miles which is replenished by water flows from the San Gabriel Mountains, including the Arroyo Seco (groundwater basins are shown in Figure 5). The Raymond Basin is an important source of drinking water for many communities in the area including Alhambra, Altadena, Arcadia, La Cañada-Flintridge, Pasadena, San Marino, and Sierra Madre. Sixteen water purveyors, who are each allowed to pump a certain amount of water per year, supply groundwater from the Raymond Basin to the public. In 1994 the Superior Court of California approved the Raymond Basin Judgement, which adjudicated the rights to groundwater production to preserve the safe yield of the groundwater basin (Raymond Basin, 1998b). Under authority of a 1984 court order, the Raymond Basin Management Board, made up of representatives of the water purveyors, oversees the management and protection of the Raymond Basin (Raymond Basin, 1997a, 1997b). A total of six Raymond Basin water purveyors operate wells within 4 miles of JPL. The closest—within 2,500 feet of JPL—are four drinking water wells, directly east of the Arroyo Seco, that are operated by the city of Pasadena. Other nearby municipal wells are located in Altadena, La Cañada-Flintridge, and Pasadena (locations of nearby drinking water wells and monitoring wells are shown in Figure 6).

The climate in Pasadena is semiarid and is characterized by hot, dry summers and mild winters with intermittent rain. The average annual precipitation in the area is 22.5 inches. The local aquifer is recharged by both natural infiltration of precipitation and artificial recharge from spreading grounds located on the eastern edge of the Arroyo Seco. The spreading basins and the Arroyo Seco are used for flood control during rainy months (December to March), when the intermittent stream running through the arroyo reaches its highest levels. The arroyo drains into the Devil's Gate Reservoir located 1 mile south of JPL. The reservoir is formed by the Devil's Gate Dam, which is situated at the southern edge of the reservoir by Interstate 210. The level of the reservoir fluctuates during the year, with little or no standing water present during dry seasons. During major floods, water has risen over portions of Oak Grove Park to the west and the spreading basins to the east. The Devil's Gate Dam and Reservoir are currently undergoing renovations that should result in a several-acre-large permanent pond. The level of this pond will be raised and lowered throughout the year to maintain proper flow downstream of the dam. There are no other lakes, ponds, or wetlands in the vicinity of JPL.

Quality Assurance and Quality Control

In preparing this public health assessment (PHA), ATSDR relied on the information provided in the referenced documents and from the referenced contacts. ATSDR assumes that adequate quality assurance and control measures were followed with chain-of-custody, laboratory procedures, and data reporting. The validity of the analyses and conclusions drawn in this document are dependent on the availability and reliability of the referenced information.

COMMUNITY HEALTH CONCERNS.

On December 2 and 3, 1997, ATSDR held four public availability sessions near JPL to provide community members an opportunity to ask questions and voice their concerns regarding public health issues at JPL. Eleven community members attended and expressed concerns regarding the following issues:

- *Future groundwater and drinking water quality.* Although the water purveyors surrounding JPL are presently able to provide drinking water that meets regulatory standards, they are concerned that further degradation of groundwater quality (or more restrictive water standards, especially for perchlorate) could prohibit them from using groundwater without costly treatment systems or system upgrades and could force them to shut down some drinking water wells. Purveyors would have to replace their lost groundwater capacity by purchasing imported water.

- *Hodgkin's disease.* Community members discussed a perceived increased incidence of Hodgkin's disease in communities surrounding JPL.

In 1994, JPL prepared a Superfund Community Relations Plan that summarized the results of two rounds of interviews, conducted in 1991 and 1993, with a total of 43 members of the surrounding communities. Through these interviews, JPL found that overall awareness of environmental problems at the facility was low (JPL, 1994c). Nevertheless, interviewees did express concerns regarding the following issues:

- Groundwater and drinking water quality
- Current hazardous waste disposal practices
- Air quality

Since these interviews, JPL has conducted remedial investigation/feasibility study (RI/FS) activities at the facility and the surrounding communities that address these health and environmental concerns. ATSDR has thoroughly reviewed all available documents for each OU, including data generated by the ongoing RI/FS activities. ATSDR has also reviewed water quality data from the six nearby water purveyors.

ENVIRONMENTAL CONTAMINATION AND POTENTIAL PATHWAYS OF EXPOSURE

In this section, ATSDR evaluates potential exposure pathways to determine whether people accessing or living near JPL could have been, are, or will be exposed to site-related contaminants via ingestion, dermal (skin) contact, or inhalation. Exposure pathways are considered "complete" when exposure to contaminated media occurs. To determine whether completed pathways pose a potential public health hazard, ATSDR compares contaminant concentrations to health-based comparison values (CVs). If contaminant concentrations are above CVs, ATSDR further analyzes exposure variables (e.g., duration and frequency) and the toxicology of the contaminant. Figure 7 summarizes ATSDR's exposure evaluation process. Table 2 presents the completed and potential exposure pathways at JPL. The following discussion evaluates potential human exposure via contaminated groundwater and soil.

ATSDR uses CVs to determine which contaminants require further evaluation within an exposure pathway. Because CVs do not represent thresholds of toxicity, exposure to contaminants at concentrations above CVs does not necessarily cause adverse health effects. CVs used in this document include EPA's maximum contaminant limits (MCLs); and ATSDR's environmental media evaluation guides (EMEGs), reference dose media guides (RMEGs), and cancer risk evaluation guides (CREGs). MCLs are enforceable drinking water regulations developed to protect public health, but they also consider economic and technological factors. CREGs, EMEGs, and RMEGs are strictly CVs developed by ATSDR and are not enforceable. Appendix D further describes the CVs used in this PHA.

Evaluation of Groundwater Exposure Pathway

Has groundwater contamination from the JPL site resulted in municipal drinking water that is unsafe for local residents or JPL employees to drink?

Conclusions

Groundwater at JPL has not affected the health of facility employees because on-site groundwater has never been used for drinking water.

Off-site groundwater with VOC contamination does not present a past, present, or future public health hazard because water purveyors, under the supervision of California Department of Health Services (CDHS), have regularly monitored drinking water wells and taken steps (e.g., water blending, water treatment, or well closure) to ensure that the water distributed to consumers is safe. These actions will continue to prevent exposures to contaminated groundwater in the future. Further degradation of groundwater quality could, however, lead to increases in the cost of water if water purveyors are forced to build treatment systems, increase their treatment capacities, and/or buy imported water.

Perchlorate contamination in off-site groundwater presents no apparent present or future public health hazard. The current sampling and blending procedures used by the drinking water purveyors near JPL are expected to prevent any potential present or future public health hazards posed by perchlorate in groundwater. If perchlorate levels continue to rise, however, these water purveyors could be forced to close down drinking water wells and buy imported water instead. Past exposures to perchlorate contamination present an indeterminate public health hazard because there are no data on perchlorate levels before 1997. Based on the available data, however, it is unlikely that past perchlorate levels in groundwater posed a public health hazard.

Discussion

Hydrogeology and Groundwater Use

As discussed in "Land Uses and Natural Resources," JPL is situated in the Raymond Basin aquifer, which is a significant source of drinking water for many nearby communities. Groundwater has been encountered in monitoring wells at JPL at depths of 100 to 240 feet below ground surface. Groundwater flows predominantly south and southeast from JPL towards the Arroyo Seco, although the direction can change, and even reverse for short periods of time, depending on seasonal variations, pumping rates of the various supply wells in the area, and the quantity of infiltration of surface runoff water in the Arroyo Seco basins (see Figure 8) (Ebasco, 1993). Groundwater elevations at JPL are generally lower between July and December and higher between January and June.

Thrust faults in the vicinity of JPL include the Mount Lukens Thrust Fault, the south branch of the San Gabriel Thrust Fault, and the JPL Thrust Fault. These faults comprise part of the Sierra Madre Fault system that separates the San Gabriel Mountains from the Raymond Basin. The JPL Thrust Fault runs along the hillside at the uphill edge of the JPL campus, and creates an uplifted, or perched, aquifer that is separate from the larger regional aquifer (this uplifted aquifer is shown in Figure 3)(Ebasco, 1993).

Located within 4 miles of JPL are drinking water wells operated by six water purveyors (municipal wells are shown in Figure 6). To the west there are four wells operated by the Valley Water Company and one well operated by the La Cañada Irrigation District. To the east and southeast there are four wells operated by the city of Pasadena, two wells operated by the Lincoln Avenue Water Company, two wells operated by the Rubio Canyon Land and Water Company, and one well operated by the Los Flores Water Company. Table 1 summarizes information about each of these drinking water sources.

Groundwater Quality and Sources of Contamination

Through the RI and previous investigations, JPL has installed a total of 19 monitoring wells on site and in the adjacent Arroyo Seco (monitoring wells are shown in Figure 6). Many of these wells have screens at several different depths in the aquifer to provide information about the three-dimensional distribution of contaminants beneath JPL. Since August 1996, JPL has sampled its monitoring wells quarterly and analyzed the samples for VOCs and metals; JPL now analyzes these quarterly samples for perchlorate, as well (Foster Wheeler, 1997a, 1997b).

As part of the RI/FS, JPL has also installed five off-site monitoring wells to the south and east of the facility, in Altadena, Pasadena, and Oak Grove Park (see Figure 6). These wells will help identify groundwater contamination that may have migrated from JPL and determine the horizontal and vertical extent of contamination. JPL also samples these wells quarterly.

VOC contamination has been detected in the drinking water wells of three water purveyors adjacent to JPL: the city of Pasadena and the Lincoln Avenue Water Company, to the east of JPL; and Valley Water Company, to the west. At various times the concentrations of VOCs in some of these wells have exceeded drinking water standards and the purveyors have shut down some drinking water wells. Since water purveyors sample their groundwater for VOCs periodically rather than continuously (sampling schedules are discussed below), for short periods of time these purveyors may have provided drinking water containing VOCs above drinking water standards. For all three purveyors, however, VOCs have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure. Concentrations of contaminants detected above drinking water standards are included for each water purveyor in Table 1. Each of these water purveyors now operates some type of water treatment system (e.g., air stripping or activated carbon filtering) to remove VOCs. Since the VOC levels vary among their drinking water wells, these water purveyors are often able to blend water from different wells to reduce the overall VOC concentrations to below drinking water standards. The purveyors also have the option of blending their well water with imported water; purveyors prefer not to do this, however, because the cost of imported water is generally much higher than the cost of water treatment (Raymond Basin, 1997a). Despite the VOC-contaminated raw water, the water purveyors adjacent to JPL manage, through treatment and blending, to produce finished water to customers that meets drinking water standards.

CDHS oversees drinking water quality in California through its Domestic Water Quality and Monitoring Regulations (Chapter 15, Title 22, California Code of Regulations). These regulations require a water purveyor to perform the following VOC sampling of raw water and submit the results to CDHS (Raymond Basin, 1998a):

- Sample before beginning water distribution operations.

- Sample every three years unless or until VOCs are detected.

- Sample quarterly once VOCs have been detected, unless or until the contaminant concentration exceeds the drinking water standard. The water purveyor is required to take steps to reduce the contaminant concentration or shut down the contaminated well. If this occurs the water purveyor must also inform its customers about the detected contamination.

- On a case-by-case basis, sample finished water if detections exceed drinking water standards in raw water. This sampling is usually required monthly.

The presence of perchlorate in groundwater did not become a concern until a sensitive test to detect perchlorate was introduced in early 1997. Since then, CDHS has recommended that water purveyors and responsible parties at hazardous waste sites analyze groundwater for perchlorate using the new test method. CDHS has set a conservative provisional drinking water standard (called an "action level") of 18 parts per billion (ppb). Perchlorate has been detected above this action level (maximum detection=615 ppb) in monitoring wells at JPL and in the Arroyo Seco (Foster Wheeler, 1997b). Perchlorate has been detected above the action level in the Pasadena drinking water well located closest to JPL (the Arroyo Well, shown in Figure 6). The city of Pasadena has since closed this well. Perchlorate levels have recently risen above the action level in the next Pasadena well downgradient to JPL, Well No. 52. By blending the water from this well with water from the remaining drinking water wells, Pasadena has been able to avoid shutting down Well No. 52 while still providing finished water that is below the action level for perchlorate (City of Pasadena, 1998). Perchlorate has been detected below the action level in the other two

Pasadena drinking water wells and in the wells of other nearby water purveyors. (See Appendix B for a summary of available information on perchlorate and its occurrence at JPL.)

There are a number of suspected contaminant source areas at JPL. These source areas include seepage pits, waste pits, stormwater discharge points, and spill areas where hazardous waste may have been released indirectly to groundwater through the soil. While contaminated groundwater on site is addressed as OU 1, the source areas are addressed in OU 2. Information on these source areas is summarized in Table 1.

The available data indicate that JPL is a source of VOC and perchlorate contamination in both on-site and off-site groundwater. Additional potential off-site sources of contamination may also exist in the area based on the following information:

- PCE and TCE are present in Valley Water Company wells (JPL, 1997d; Raymond Basin, 1997a). PCE has not been detected in significant amounts at JPL.

- Areas of La Cañada-Flintridge without sewers use septic systems. According to JPL and the Valley Water Company, citizens in these areas have often cleaned their plumbing pipes by pouring solvent down their drains (JPL 1997a; Raymond Basin, 1997a).

- Groundwater investigations performed by JPL indicate that VOC concentrations beneath JPL vary seasonally and may indicate the presence of an off-site source in addition to on-site sources (JPL 1997b). Future groundwater investigations conducted by JPL may therefore shed light on the existence of a possible additional source of contamination.

Exposure Pathway Evaluation

No exposure to contaminated groundwater has occurred at JPL because on-site groundwater has never been used for drinking water at the facility. VOC-contaminated groundwater has been detected in drinking water wells of three water purveyors near JPL (city of Pasadena, Lincoln Avenue Water Company, and Valley Water Company). This contamination has been detected through routine sampling, and as these contaminant levels have risen, the water purveyors, under the supervision of CDHS, have taken actions (e.g., water-blending, water treatment, and well closure) to ensure that the finished water distributed to customers meets drinking water standards (Raymond Basin, 1997a). VOC contamination has not been detected or has not exceeded standards in drinking water wells located farther away from JPL (La Cañada Irrigation District, Rubio Canyon Land and Water Company, and Los Flores Water Company) (JPL, 1997d; La Cañada, 1998; Rubio Canyon, 1998; Los Flores, 1998).

Perchlorate has been detected above the CDHS action level in two Pasadena drinking water wells. By closing one well and blending water from the second well with the remaining drinking water wells, Pasadena is producing finished water that is below the action level for perchlorate (City of Pasadena, 1998). Perchlorate has been detected below the action level in numerous other drinking water wells near JPL. CDHS requires regular sampling of drinking water wells where perchlorate concentrations are of potential concern. This regular sampling, together with water blending or well closures (when necessary), now ensures that all water distributed to consumers meets California's action level for perchlorate. ATSDR believes that these actions will continue to eliminate any potential public health hazard posed by exposure to perchlorate in groundwater near JPL.

Perchlorate levels in and around JPL before 1997 are unknown. The rise in perchlorate levels observed during 1997 in the Pasadena wells may indicate that perchlorate levels were lower in the past. Although the Arroyo Well had perchlorate levels above the action level when perchlorate analysis began, the other three Pasadena wells did not, so the blended water from these four wells probably did not exceed the action level. In addition, this action level is very conservative. For these reasons, it is unlikely that past perchlorate levels in groundwater have posed a public health hazard. However, because there is no information on past perchlorate levels, ATSDR has assigned past exposures to perchlorate in off-site groundwater to the indeterminate public health hazard category.

Evaluation of Soil Exposure Pathway

Could exposure to soil contamination at JPL result in adverse human health effects?

Conclusion

No public health hazards are associated with exposure to contaminated soils at JPL. Contaminants in on- and off-site (in the Arroyo Seco near the JPL boundary) soils were detected at levels that pose no public health hazard and were inaccessible to JPL workers or the public because of their depth below the ground's surface or were located where exposure was infrequent or unlikely. VOC vapors were detected in relatively shallow soil in the area of Building 107, but indoor air quality sampling in this building detected no VOC vapors.

Discussion

Extent and Sources of Soil Contamination

The pre-RI and RI activities for OU 2 has involved measurement of soil gas through probes and wells and collection of subsurface soil samples from over 40 suspected contaminant source areas at JPL and nearby in the Arroyo Seco (Ebasco, 1993; Foster Wheeler, 1997c). Locations of suspected contaminant sources are shown in Figure 9. Information on these sources is summarized in Table 1. Samples of surface soil (0 to 6 inches deep) generally were not collected at JPL, because most of the suspected source areas are buried beneath pavement, buildings, retaining walls, or flower planters (Foster Wheeler, 1998). At areas that are exposed at the surface (e.g., the stormwater discharge points), soil sampling began at depths of 1 foot or more. For these areas, ATSDR considered the shallowest samples to be representative of surface soil. Subsurface soil sampling has detected no contamination at levels above health-based CVs. Soil-gas sampling has detected areas of soil contamination:

- VOC vapors were detected above CVs for air in numerous soil-vapor probes and monitoring wells at JPL. Most of the detections that exceeded CVs were at depths of 80 to 200 feet below ground surface. CTC was detected above its CV at depths of 11 to 13 feet in soil-vapor probes 31 and 33, which were taken at two locations near Building 107. Locations of the soil-vapor probes are shown in Figure 10.

Exposure Pathway Evaluation

The majority of suspected contaminant source areas at JPL are located beneath pavement, buildings, retaining walls, and flower planters and are not accessible to JPL employees (the types of cover over each source area are specified in Table 1). In addition, soil sampling has detected no contaminants at concentrations above CVs, although soil-gas sampling has detected VOC vapors above CVs. Although workers could be exposed to currently inaccessible subsurface soils during future excavation, demolition, or construction work, ATSDR assumes that these workers will wear proper protective equipment in accordance with the Occupational Safety and Health Administration (OSHA) regulations.

VOCs were detected above CVs for air in numerous soil-vapor probes and soil-vapor well samples. The majority of these detections were at depths of 80 to 200 feet and are not expected to pose a public health hazard to JPL workers. CTC vapors were detected above CVs at depths of 11 to 13 feet in soil-vapor probes 31 and 33, located directly south of Building 107. VOC vapors in soil at relatively shallow depths have the potential to collect in the lower levels of buildings, where they can pose a public health hazard. Soil-vapor measurements from soil-vapor probes are not necessarily indicative of VOC concentrations in the air at a nearby building, but they can indicate areas where indoor air sampling might be required. In response to ATSDR concerns about potential VOC vapors in indoor air, JPL performed indoor air quality sampling at Building 107. This sampling indicated that VOC vapors were not present in the building.

ATSDR CHILD HEALTH INITIATIVE

ATSDR recognizes that infants and children may be more sensitive to exposures than adults in communities with contamination of their water, soil, air, or food. This sensitivity is a result of the following factors: Children are more likely to be exposed to soil or surface water contamination because they play outdoors and often bring food into contaminated areas. For example, children may come into contact with and ingest soil particles at higher rates than do adults; also, some children with a behavior trait known as "pica" are more likely than others to ingest soil and other nonfood items. Children are shorter than adults, which means they can breathe dust, soil, and any vapors close to the ground. Also, they are smaller, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at sites such as JPL.

ATSDR has attempted to identify populations of children in the vicinity of JPL and any completed exposure pathways to these children. Children are not regularly or normally present at JPL, although children of JPL employees may visit JPL on occasion. JPL offers a day care service for its employees at a facility located southeast of JPL near La Cañada High School. The following schools are located within one mile southeast of JPL: Flintridge School for Boys, St. Bede School, St. Francis High School, Oak Grove School, and La Cañada High School. Located within one mile east or southeast of JPL are Mt. Lowe Academy, Audubon School, Sacred Heart School, Franklin School, and Five Acres School. These schools are shown in Figure 1. Roughly 1,500 children under the age of ten are estimated to live within 1 mile of JPL. ATSDR did not identify any completed exposure pathways from JPL that are specific to children at nearby schools or residential areas. Like all other people living or working in the vicinity of JPL, children ingest drinking water—supplied by local water purveyors—that has, at least in part, been pumped from aquifers near JPL. This potential groundwater exposure pathway is discussed extensively in "Environmental Contamination and Potential Pathways of Exposure."

CONCLUSIONS

Based on an evaluation of available environmental information, ATSDR has reached the following conclusions:

- On-site groundwater at JPL does not present a past, present, or future public health hazard because on-site groundwater has never been used for drinking and there are no plans to use this groundwater in future.

- VOC contamination in off-site groundwater does not present a past, present, or future public health hazard because water purveyors, under the supervision of CDHS, have regularly monitored drinking water wells and taken steps (e.g., water blending, water treatment, or well closure) to ensure that the water distributed to consumers is safe. These actions will continue to prevent exposures to contaminated groundwater in the future. Further degradation of groundwater quality could, however, lead to increases in the cost of water if water purveyors are forced to build treatment systems, increase their treatment capacities, and/or buy imported water.

- Perchlorate contamination in off-site groundwater presents no apparent present or future public health hazard. The current sampling and blending procedures used by the drinking water purveyors near JPL are expected to prevent any potential present or future public health hazards posed by perchlorate in groundwater. If perchlorate levels continue to rise, however, these water purveyors could be forced to close down drinking water wells and buy imported water instead. Past exposures to perchlorate contamination present an indeterminate public health hazard because there are no data on perchlorate levels before 1997. Based on the available data, however, it is unlikely that past perchlorate levels in groundwater have posed a public health hazard.

- No public health hazards are associated with exposure to contaminated soils at JPL. Contaminants in on- and off-site (in the Arroyo Seco near the JPL boundary) soils were detected at levels that pose no public health hazard and were inaccessible to JPL workers or the public because of their depth below the ground's surface or were located where exposure was infrequent or unlikely. VOC vapors were detected in relatively shallow soil in the area of Building 107, but indoor air quality sampling in this building detected no VOC vapors.

- Community members expressed concern about a perceived increased incidence of Hodgkin's disease in communities surrounding JPL. Hodgkin's disease is not known to be associated with exposure to any chemical, however.

PUBLIC HEALTH ACTION PLAN

The public health action plan (PHAP) for JPL contains a description of actions taken and those to be taken by ATSDR, JPL, EPA, and CDHS at and in the vicinity of JPL after the completion of this PHA. The purpose of the PHAP is to ensure that this PHA not only identifies ongoing and potential public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The public health actions that are completed, being implemented, planned, or recommended are as follows:

Completed Actions

- JPL and the city of Pasadena installed a treatment system in 1990 to remove VOCs from groundwater detected in Pasadena drinking water wells located east/southeast of JPL.

- All water purveyors in the vicinity of JPL, under the supervision of CDHS, have taken steps (e.g., sampling, water blending, water treatment, well closure) to ensure that all drinking water supplied to consumers meets drinking water standards.

- JPL performed indoor air quality sampling to ensure that VOC vapors detected in shallow soil near Building 107 are not collecting inside the building.

Ongoing and Planned Actions

- JPL is preparing a RI report for OUs 1 and 3, scheduled for completion in March 1999. ATSDR will evaluate this report when it becomes available. This report will be available to the public.

- Federal and state regulators are awaiting JPL's RI report for OU 2. ATSDR will evaluate this report when it becomes available. This report will also be available to the public.

- When sufficient information on the toxicological effects of perchlorate become available, ATSDR will review the available information on perchlorate in nearby drinking water wells and further evaluate any potential public health hazards that may have been posed by exposure to perchlorate in groundwater.

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; also known as Superfund), as amended, requires ATSDR to conduct needed follow-up health actions in communities living near hazardous waste sites. To identify appropriate action, ATSDR created the Health Activities Recommendation Panel (HARP). HARP has evaluated the data and information contained in the National Aeronautics and Space Administration Jet Propulsion Laboratory (JPL) Public Health Assessment for appropriate pubulic health actions. No follow-up health activities are recommended at JPL because there is no know exposure at this site at levels known to pose a public health hazard.

PREPARERS OF REPORT

W. Mark Weber, Ph.D.
Geologist/Environmental Health Scientist
Federal Facilities Assessment Branch
Division of Health Assessment and Consultation

Gary Campbell, Ph.D.
Environmental Health Scientist
Federal Facilities Assessment Branch
Division of Health Assessment and Consultation

REFERENCES

Bookman-Edmonston. 1997. Draft Raymond Groundwater Basin Perchlorate Contamination Problem Work Plan. Prepared by Bookman-Edmonston Engineering for the Raymond Basin Management Board. September 1997.

CDHS. 1997. Perchlorate in Drinking Water. Fact Sheet. California Department of Health Services. May 1997.

City of Pasadena. 1998. Personal communication with Brad Bowman, Principal Engineer, City of Pasadena Water and Power Department. February 19, 1998.

Ebasco. 1990a. Expanded Site Inspection Report, NASA-Jet Propulsion Laboratory. Prepared by Ebasco Environmental for NASA-JPL, Pasadena, CA. May 1990.

Ebasco. 1990b. Supplemental Information to the Expanded Site Inspection Report, NASA-Jet Propulsion Laboratory: Hazard Ranking System Documentation. Prepared by Ebasco Environmental for NASA-JPL, Pasadena, CA. November 1990.

Ebasco. 1993. Work Plan for performing a Remedial Investigation/Feasibility study, NASA-Jet Propulsion Laboratory. Prepared by Ebasco Environmental for NASA-JPL, Pasadena, CA. December 1993.

Foster Wheeler. 1997a. Report: Quarterly Groundwater Monitoring Results, February-March 1997. Prepared by Foster Wheeler Environmental Corporation for NASA-JPL, Pasadena, CA. April 1997.

Foster Wheeler. 1997b. Report: Quarterly Groundwater Monitoring Results, June-July 1997. Prepared by Foster Wheeler Environmental Corporation for NASA-JPL, Pasadena, CA. September 1997.

Foster Wheeler. 1997c. Soil-vapor probe, soil-vapor well, and soil boring data collected during RI activities for OU 2. Presented by Foster Wheeler Environmental Corporation to ATSDR on December 5, 1997.

Foster Wheeler. 1998. Personal communication with B.G. Randolph, Foster Wheeler Environmental Corporation. February 27, 1998.

Jet Propulsion Lab. *See* JPL

JPL. 1991a. Environmental Cleanup Review Fact Sheet No. 1. April 1991.

JPL. 1991b. Jet Propulsion Laboratory Closeup. September 1991.

JPL. 1994c. Superfund Community Relations Plan for National Aeronautics and Space Administration Jet Propulsion Laboratory. January 1994.

JPL. 1997a. Personal communication with Charles Buril, Manager, JPL Environmental Affairs Office. November 13, 1997.

JPL. 1997b. Superfund Project packet. Prepared for ATSDR. August 1997.

JPL. 1997c. Interoffice memorandum: Perchlorate in Drinking Water. Results from July 16, 1997 perchlorate sampling. August 15, 1997.

JPL. 1997d. Water sampling data from area water purveyors. Provided to ATSDR December 3, 1997 and June 24, 1998.

JPL. 1997e. Personal communication with Charles Buril, Manager, JPL Environmental Affairs Office. August 20, 1997.

JPL. 1998. Personal communication with Charles Buril, Manager, JPL Environmental Affairs Office. February 18, 1998.

La Cañada. 1998. Personal communication with Doug Laister, Engineer, La Cañada Irrigation District. February 19, 1998.

Lincoln Avenue. 1998. Personal communication with Bob Heyward, Engineer, Lincoln Avenue Water Company. February 19, 1998.

Los Flores. 1998. Personal communication with Ken Vader, Engineer, Los Flores Water Company. March 3, 1998.

Raymond Basin. 1997a. Personal communication with members of Raymond Basin Management Board. December 3, 1997.

Raymond Basin. 1997b. Watermaster Service in the Raymond Basin. July 1, 1996–June 30, 1997. September 1997.

Raymond Basin. 1998a. Personal communication with Ronald Palmer, Executive Officer, Raymond Basin Management Board. February 10, 1998.

Rayond Basin. 1998b. Comments on the Draft Public Health Assessment for the Jet Propulsion Laboratory. May 14, 1998.

Rubio Canyon. 1998. Personal communication with Wally Weaver, Engineer, Rubio Canyon Land and Water Company. March 5, 1998.

Valley Water. 1998. Personal communication with Andy Boytim, Engineer, Valley Water Company. February 19, 1998.

TABLES

TABLE 1: EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 1: On-site Groundwater				
Groundwater	Carbon tetrachloride (CTC), tetrachloroethylene (PCE), and trichloroethylene(TCE) were discovered in on-site groundwater in 1990. Perchlorate was discovered in 1997.	Since long-term on-site groundwater monitoring began in August 1996, CTC (nondetectable (ND)-170 ppb) has been detected above maximum contaminant levels (MCLs) in 12 wells; TCE (ND-47 ppb) has been detected above MCLs in eight wells; and dichloroethane (DCA) (ND-2.5 ppb) has been detected above MCLs in four wells. Perchlorate analysis in June-July 1997 indicated concentrations (ND-615 ppb) above California's action level in six wells.	Quarterly groundwater monitoring continues to track contaminant movement. No treatment is currently being performed. The remedial investigation/feasibility study (RI/FS) is ongoing and is scheduled for completion in early 1999. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing volatile organic compound (VOC) vapors in soil that may be contaminating groundwater on site.	No public health hazard is associated with groundwater at JPL because there is no known exposure to groundwater on site.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
		OU 2: On-site Contamination Sources		
The following seepage pits and waste pits were used between 1940 and 1960 for disposal of liquid hazardous wastes.				
Seepage Pits 1, 2, 3, 4, and 35	Seepage Pits 1, 2, and 35 are located beneath a paved parking lot north of Building 11, and Seepage Pits 3 and 4 are located beneath flower planters west and north of Building 11, respectively; these sites are inaccessible to JPL employees. Seepage Pits 1 and 2 are located in the area with the longest history of use at JPL. Seepage Pits 3 and 4 apparently were connected to Building 11, where solvents may have been used for plumbing and electrical work. Seepage Pit 35 was connected to former Building 81, which housed workshops, storage rooms, and offices.	Seepage Pit 4 was inaccessible to soil boring. Sampling at Seepage Pits 1 and 35 was performed during a pre-RI investigation. **Soil gas:** Chloroform, CTC, dichloroethene (DCE), and 1,1,1-trichloroethane (TCA) were detected in one or more of these seepage pits. **Subsurface soil**[1]**:** One semivolatile organic compound (SVOC) was detected below comparison values (CVs) in one sample. No metals were detected above CVs.	No treatment is currently being performed on any OU 2 sites. The RI report for OU 2 is under review by regulators, and will be followed by the FS report. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing VOC vapors from soil.	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 5	This site is located beneath a lawn and concrete sidewalls east of Building 277. Seepage Pit 5 was associated with former Buildings 68, 71, and 127, which may have been used to store solvents used in mixing and developing propellants.	**Soil gas:** CTC, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard. This seepage pit is believed to be buried and is unlikely to have contaminated the surface soil of the lawn.
Seepage Pit 6	This seepage pit is located beneath Mariner Road just south of Building 277 and is inaccessible to JPL employees. This seepage pit may have been associated with the same contaminant sources as Seepage Pits 1, 2, 3, 4, and 5.	**Soil gas:** CTC, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 7, 7A, and 7B	Seepage Pit 7 is located beneath Building 103, and Seepage Pits 7A and 7B are located beneath an electrical substation south of Building 103; these sites are inaccessible to JPL employees. Building 103 housed machine, fabrication, and metal shops; solvents and other liquids were allegedly dumped in a drain hole in the floor (Seepage Pit 7).	**Soil gas:** CTC and TCE were detected. **Subsurface soil:** One SVOC was detected below CVs in one soil sample. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pits 8, 9, 13, and 13A	Seepage Pits 8, 13, and 13A are located beneath Building 302 and are inaccessible to JPL employees. Seepage Pit 9 is also suspected to be located under Building 302, but its exact location is unknown. Seepage Pit 8 is a dry well the drained liquids from a testing machine. Seepage Pit 9 may have been connected to a small workshop at former Building 13 or to the credit union at former Building 44. Seepage Pits 13 and 13A may have been connected to a materials and/or chemistry laboratory, and drained to Seepage Pit 8.	Seepage Pits 8, 13, and 13A were inaccessible to soil probing or boring. **Soil gas:** No VOCs were detected at Seepage Pit 9.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pits 10 and 12	Seepage Pit 10 is located beneath pavement, a retaining wall foundation, and bank of nitrogen tanks east of Building 78. Seepage Pit 12 is located beneath a flower bed and pavement south of Building 78. These sites are inaccessible to JPL employees. Building 78 reportedly housed a hydraulics laboratory and chemical test cell; solvents used for cleaning and degreasing were reportedly dumped into drains.	Seepage Pit 10 was inaccessible to soil boring. **Soil gas:** Chloroform, CTC, Freon, PCE, and/or TCE were detected at these sites. **Subsurface soil:** One SVOC was detected below CVs in one sample from Seepage Pit 12. No metals were detected above CVs in Seepage Pit 12.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pit 11	Seepage Pit 11 is located beneath a planted slope and a retaining wall foundation north of Building 113. Seepage Pit 11 was associated with former Building 104, which collected sanitary waste, and Building 101, which may have collected solvent and hydrocarbon wastes.	Seepage Pit 11 was inaccessible to soil boring. **Soil gas:** CTC was detected at this site.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard. Seepage Pit 11 is believed to be buried and is unlikely to have contaminated the surface soil of the planted slope it is partially beneath.
Seepage Pit 14	This site is located beneath the paved patio entryway to Building 302 and is inaccessible to JPL employees. This seepage pit is associated with the same contamination sources as Seepage Pits 10 and 12.	**Soil gas:** Chloroform, CTC, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 15 and 16	Seepage Pit 15 is located beneath the foundation of Building 300, and Seepage Pit 16 is located beneath the north end of the paved patio on the east side of Building 303; these sites are inaccessible to JPL employees. Seepage Pit 15 was associated with old test cell buildings and a liquid testing facility where small spills of solvents reportedly occurred over the years. Seepage Pit 16 may have been used for disposal of paint solvents.	**Soil gas:** CTC, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 17	This site is located beneath a planted slope located near Building 280. The seepage pit was associated with former Building 55, a solid propellant mixing facility where solvents were reportedly disposed of in sumps.	**Soil gas:** CTC, DCE, and Freon were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard. Seepage Pit 17 is believed to be buried and is unlikely to have contaminated the surface soil of the planted slope it is beneath.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 18, 19, and 30	Seepage Pit 18 is located beneath Pioneer Road, and Seepage Pit 30 is located beneath a paved parking area off Pioneer road south of Building 117; these sites are inaccessible to JPL employees. Seepage Pit 19 is located beneath Pioneer Road and a planted slope. These seepage pits were associated with a solid propellant test cell where tubs of solvent (e.g., CTC and acetone) were reportedly disposed of in sumps and drains.	Sampling at Seepage Pit 18 was performed during a pre-RI investigation. **Soil gas:** Freon and DCE were detected at Seepage Pit 19 and Freon and TCE were detected at Seepage Pit 30. No VOCs were detected at these sites. **Subsurface soil:** No VOCs were detected in Seepage Pit 18. No SVOCs were detected at Seepage Pits 19 or 30. No metals were detected above CVs in Seepage Pits 18, 19, or 30.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard. Seepage Pit 19 is believed to be buried and is unlikely to have contaminated the surface soil of the planted slope it is partially beneath.
Seepage Pits 20 and 21	These sites are located beneath or behind retaining wall foundations and are inaccessible to JPL employees. These seepage pits were associated with compressors and a maintenance shop where solvents were used.	These seepage pits were sampled through a single boring. **Soil gas:** Chloroform, CTC, DCE, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 22	This site is located beneath office trailers and is inaccessible to JPL employees. This seepage pit is associated with the former wind tunnel building, which had no history of solvent or chemical use.	No sampling has been performed at this site.	See Seepage Pit 1	No public health hazard is associated with this site because there is no evidence that the site ever contained hazardous materials.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 23, 24, and 25	Seepage Pits 23 and 24 are located beneath the paved parking area along Explorer Road south of Building 67, and Seepage Pit 25 is located beneath a paved walkway southeast of Building 67; these sites are inaccessible to JPL employees. Although Building 67 has been used primarily as an office building, at one time it did contain small laboratories that may have been connected to seepage pits.	Seepage Pit 25 was inaccessible to soil boring. **Soil gas:** CTC, DCE, Freon, and TCE were detected at Seepage Pits 23 and 24. **Subsurface soil:** One SVOC was detected below CVs in one sample from Seepage Pits 23 and 24. No metals were detected above CVs in Seepage Pits 23 or 24.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 26 and 28	Seepage Pit 26 is located beneath Building 299, and Seepage Pit 28 is located beneath a flower planter and Pioneer Road, south of Building 299; these sites are inaccessible to JPL employees. These seepage pits are associated with Building 299, which housed an experimental chemistry laboratory, fluorine propellant test cell, and acid-neutralizing pit. Numerous chemicals were reportedly disposed of in sumps near the building.	Seepage Pit 28 was inaccessible to soil boring. Sampling at Seepage Pit 26 was performed during a pre-RI investigation. **Soil gas:** DCE and TCA were detected at Seepage Pit 26. **Subsurface soil:** No VOCs or SVOCs were detected at Seepage Pit 26.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 27	This site is located beneath the paved parking lot southeast of Building 246 and is inaccessible to JPL employees. This seepage pit was connected to a soils test laboratory which had no history of solvent or chemical usage.	This site was investigated during the pre-RI investigation. The site was ruled out as suspected contamination source area.	See Seepage Pit 1	No public health hazard is associated with this site because there is no evidence that the site ever contained hazardous materials.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 29 and 31	Seepage Pits 29 and 31 are located beneath paved parking/driveway areas off of Explorer Road and are inaccessible to JPL employees. These seepage pits were associated with solid and liquid propellant test cells where solvents were used.	Sampling at Seepage Pit 31 was performed during a pre-RI investigation. **Soil gas:** High levels of CTC, as well as chloroform and TCE, were detected at Seepage Pit 31. CTC, Freon, and TCE were detected at Seepage Pit 29. **Subsurface soil:** No VOCs were detected at Seepage Pit 31. No SVOCs were detected at these seepage pits. No metals were detected above CVs at these seepage pits.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pits 32 and 34	Seepage Pit 32 is located beneath a paved walkway south of Building 86, and Seepage Pit 34 is located beneath the paved driveway northeast of Building 98; these sites are inaccessible to JPL employees. These seepage pit were located at the eastern end of a solid propellant preparation area and were reportedly used to dispose of solvents and other chemicals.	Seepage Pit 32 was inaccessible to soil boring. **Soil gas:** Benzene, toluene, ethylbenzene, and xylene (BTEX), chloroform, Freon, DCA, DCE, PCE, and TCA were detected at Seepage Pit 34. **Subsurface soil:** No SVOCs were detected at Seepage Pit 34. No metals were detected above CVs in Seepage Pit 34.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 33	This site is located beneath a paved driveway west of Building 97 and is inaccessible to JPL employees. This seepage was associated with a development laboratory for solid propellant chemistry experimentation where solvents were used to clean hardware. All liquids reportedly were drained to the seepage pit.	**Soil gas:** No VOCs were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 2: Contamination Sources (continued)				
The following waste pits were used for disposal of municipal wastes and solid and liquid hazardous wastes.				
Seepage Pits 36 and 37	Seepage Pit 36 is located beneath a paved driveway, and Seepage Pit 37 is located beneath Explorer Road; these sites are inaccessible to JPL employees. Seepage Pit 36 was associated with test cells and shops along Jato Road. Seepage Pit 37 was a dry well for a former building with an unknown use.	**Soil gas:** Soil-vapor probe detected chloroform and CTC. Soil-vapor well detected CTC, chloroform, TCE, and PCE. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Waste Pits WP-1, WP-2, and WP-5	These sites are located along the eastern property boundary just south of Arroyo Road. WP-1 and WP-2 cross over the property boundary into the Arroyo Seco.	A soil-vapor probe or monitoring well has not been installed at WP-5. **Soil gas:** No VOCs were detected at these waste pits. **Subsurface soil:** No SVOCs were detected at WP-1 or WP-2. No metals were detected above CVs at WP-2. No contaminants were detected above CVs at WP-5.	No treatment is currently being performed on any OU 2 sites. The RI report for OU 2 is under review by regulators, and will be followed by the FS report. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing VOC vapors from soil.	No public health hazard is associated with these sites because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access this area, contamination was not detected at levels that pose a public health hazard.
Waste Pit WP-3	This site is located underneath a paved area along Pioneer Road southwest of Building 248 and is inaccessible to JPL employees.	**Soil gas:** Chloroform, CTC, Freon, DCE, and TCE were detected. **Subsurface soil:** One SVOC was detected below CVs in one sample. No metals were detected above CVs.	See Waste Pit WP-1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 2: Contamination Sources (continued)				
The following discharge points received stormwater runoff that may have contained hazardous materials.				
Waste Pit WP-4	This site is located along the eastern property boundary just south of Arroyo Road.	**Soil gas:** Soil-vapor well detected no VOCs. **Subsurface soil:** Polycyclic aromatic hydrocarbons (PAHs) were detected below CVs in one sample. No metals were detected above CVs.	See Waste Pit WP-1	No public health hazard is associated with this site because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access this area, contamination was not detected at levels that pose a public health hazard.
Discharge Point DP-1	DP-1 is located approximately 50 feet beyond the eastern property boundary, in the Arroyo Seco.	**Soil gas:** No VOCs were detected. **Subsurface soil:** A dioxin, PAHs, polychlorinated biphenyls (PCBs), and SVOCs were detected below CVs.	No treatment is currently being performed on any OU 2 sites. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing VOC vapors from soil.	No public health hazard is associated with this site because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access this area, contamination was not detected at levels that pose a public health hazard.
Discharge Points DP-2, DP-3, and DP-4	DP-2 and DP-4 are located near the eastern property boundary, while DP-3 is located approximately 150 feet beyond the eastern property boundary, in the Arroyo Seco.	Soil boring was performed on DP-2, while test pitting was performed on DP-3 and DP-4. **Soil gas:** No VOCs were detected at DP-2. **Subsurface soil:** PAHs were detected below CVs at DP-3. No metals were detected above CVs at DP-3 or DP-4.	See DP-1	No public health hazard is associated with these sites because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access these areas, contamination was not detected at levels that pose a public health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 2: Contamination Sources (continued)				
The following OU 2 sites are locations of miscellaneous suspected chemical releases.				
Building 197	This building was suspected to have VOC contamination as a result of wind tunnel and propellant operations.	**Soil gas:** Freon was detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	No treatment is currently being performed on any OU 2 sites. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing VOC vapors from soil.	No public health hazard is associated with this site because no contamination was detected except for low levels of Freon at depth.
Building 302	A contamination source was suspected to be located beneath Building 302, the Micro Devices Building.	Building 302 was inaccessible to soil boring. JPL attempted to investigate this source area by performing soil gas probes around the edge of the building. **Soil gas:** Soil-vapor probe detected no VOCs.	See Building 197.	No public health hazard is associated with this site because there is no completed exposure pathway to the suspected contamination source area. Sampling around the building did not detect contamination, and any contamination located beneath the building is not accessible to JPL employees.
Building 306	During excavation of the foundation for this building, JPL discovered an old landfill. This landfill is believed to predate JPL. Soil in the landfill was contaminated with oil which apparently had been used as a dust suppressor.	**Soil gas:** CTC, Freon, TCA, and TCE were detected. **Subsurface soil:** Subsurface soil samples detected no SVOCs. No metals were detected above CVs.	JPL removed approximately 20,000 cubic yards of contaminated soil. Post-excavation sampling confirmed that the contaminated soil had been removed.	No public health hazard is associated with this site because the petroleum-contaminated soil was removed.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 3: Off-site Groundwater				
City of Pasadena drinking water wells	Four drinking water wells are located within 2,500 feet southeast of JPL, just east of the Arroyo Seco. This water source, in combination with imported water, serves approximately 133,000 people in Pasadena.	Monitoring of wells in 1980 revealed low concentrations of CTC and TCE that gradually increased over time. Low levels of PCE and other VOCs have also been detected periodically. Perchlorate has been detected above California's action level in two drinking water wells and has been detected below the action level in the two other wells. CTC, perchlorate, and TCE have been detected above the MCL/action level in raw water from one or more of these supply wells. The ranges of contaminant concentrations detected above the MCL/action level are as follows: **Contaminant** / **Range** / **MCL** **CTC** 5.1 - 13.0 ppb 5 ppb **Perchlorate** 90 - 145 ppb 18 ppb **TCE** 5.0 - 32.0 ppb 5 ppb	Two wells were closed in 1985, and two more were closed in 1989 when contaminants exceeded drinking water standards. In 1990, JPL and the city of Pasadena constructed a water treatment plant to remove VOCs from the water and allow the wells to be reopened. This treatment system consists of two air strippers with activated carbon off-gas pollution control. The Arroyo Well was closed again in 1997 due to perchlorate contamination. Perchlorate has more recently been detected above the action level in Well No. 52; by blending water from this well with water from the remaining wells, Pasadena is reducing the overall perchlorate concentration of its finished water to below the action level. Pasadena performs monthly sampling at each well for VOCs and perchlorate and performs weekly sampling of its finished water for VOCs and perchlorate. The California Department of Health Services (CDHS) reviews these sampling data.	No public health hazard is associated with VOC contamination in these wells. VOCs have been present above drinking water standards in raw water from some of these wells but, due to treatment and blending, the finished water does not contain VOCs above drinking water standards. Since water purveyors sample their groundwater for VOCs periodically rather than continuously, for short periods of time in the past finished drinking water may have contained VOCs above drinking water standards. However, VOCs in these wells have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure. Perchlorate contamination presents an indeterminate past public health hazard because groundwater was not analyzed for perchlorate until 1997. Perchlorate levels may have been lower in the past, because perchlorate levels rose throughout 1997 in the Pasadena wells. Although one Pasadena well had perchlorate levels above the action level when perchlorate analysis began, the other three wells did not exceed the action level, so the blended finished water probably did not exceed the action level. Through regular sampling and water blending, Pasadena is currently able to keep the perchlorate concentration below the action level in its finished water.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Lincoln Avenue Water Company drinking water wells	Two drinking water wells are located within 3,500 feet southeast of JPL, in Altadena. This water source serves approximately 8,000 people, primarily in Altadena.	Monitoring of wells revealed CTC, PCE, and TCE in both drinking water wells in the early 1980s that gradually increased over time. Perchlorate has been detected below California's action level in these wells. PCE and TCE have been detected above the MCL in raw water from one or more of these supply wells. The ranges of contaminant concentrations detected above the MCL are as follows: **Contaminant** / **Range** / **MCL** **PCE** 6.9 ppb* 5 ppb **TCE** 5.9 - 92 ppb 5 ppb * Only one detection was above the MCL.	These two wells were shut down in 1987 when concentrations of TCE exceeded drinking water standards. In 1992, Lincoln Avenue installed a granular activated carbon treatment system and was able to reopen its wells. Through a combination of treatment, blending, and the addition of imported water, Lincoln Avenue has kept its finished water within regulatory standards. Lincoln Avenue performs weekly sampling of its raw and finished water for VOCs and perchlorate. CDHS reviews these sampling data.	No public health hazard is associated with VOC contamination in these wells. VOCs have been present above drinking water standards in raw water from some of these wells but, due to treatment and blending, the finished water does not contain VOCs above drinking water standards. Since water purveyors sample their groundwater for VOCs periodically rather than continuously, for short periods of time in the past finished drinking water may have contained VOCs above drinking water standards. However, VOCs in these wells have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure. Perchlorate contamination presents an indeterminate past public health hazard because groundwater was not analyzed for perchlorate until 1997. In light of the current low levels of perchlorate in these wells, however, it is unlikely that past exposure to perchlorate presents a public health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Valley Water Company drinking water wells	Four drinking water wells are located within 2,500 feet west of JPL. This water source, in combination with imported water, serves approximately 10,500 people in La Cañada-Flintridge. Valley Water uses groundwater only from May through September; for the rest of the year the company relies on imported water. Although JPL is generally downgradient to the wells, increased rainfall and groundwater mounding in the Arroyo Seco can reverse groundwater flow from JPL towards these wells for short periods of time.	PCE and TCE were discovered above drinking water standards through monitoring in the 1985. Perchlorate has been detected below California's action level in these wells. PCE and TCE have been detected above the MCL in raw water from one or more of these supply wells. The ranges of contaminant concentrations detected above the MCL are as follows: **Contaminant** / **Range** / **MCL** **PCE** 5.2 - 110.0 ppb 5 ppb **TCE** 5.9 ppb* 5 ppb * Only one detection was above the MCL.	Valley Water installed an air stripper system in 1993 to treat VOCs. Through a combination of treatment, blending, and the addition of imported water, Valley Water has kept its finished water within regulatory standards. During its groundwater pumping season, Valley Water performs monthly sampling of raw water for VOCs and perchlorate and performs weekly sampling of its finished water for VOCs. CDHS reviews these sampling data.	No public health hazard is associated with VOC contamination in these wells. VOCs have been present above drinking water standards in raw water from some of these wells but, due to treatment and blending, the finished water does not contain VOCs above drinking water standards. Since water purveyors sample their groundwater for VOCs periodically rather than continuously, for short periods of time in the past finished drinking water may have contained VOCs above drinking water standards. However, VOCs in these wells have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure. Perchlorate contamination presents an indeterminate past public health hazard because groundwater was not analyzed for perchlorate until 1997. In light of the current low levels of perchlorate in these wells, however, it is unlikely that past exposure to perchlorate presents a public health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
La Cañada Irrigation District drinking water wells	Two drinking water wells are located within 3,000 feet west of JPL. This water source, in combination with imported water, has in the past served approximately 8,500 people in La Cañada-Flintridge. These wells had been inactive for some time but were reopened in 1997. Currently a relatively small water producer, the La Cañada Irrigation District is beginning an injection/ recovery operation which involves pumping imported water into the aquifer for storage and then pumping it back out during times of peak demand. Although JPL is generally downgradient to these wells, increased rainfall and mounding in the Arroyo Seco can reverse groundwater flow from JPL towards these wells for short periods of time.	Perchlorate has been detected at concentrations below California's action level. With one exception, any VOCs detected in these wells have been at concentrations below drinking water standards; VOCs temporarily exceeded water standards in one sampling round, but subsequent samples showed contamination had fallen back to below the standards. Nitrate levels have been elevated but below drinking water standards.	La Cañada currently performs yearly sampling of its raw water for VOCs and quarterly sampling for nitrates. CDHS reviews these sampling data. La Cañada has also performed some perchlorate sampling. Because the samples of raw water have met water quality standards, CDHS does not require La Cañada to sample its finished water. As La Cañada begins its injection/recovery program and become a larger water producer, CDHS may require a different sampling schedule.	No public health hazard is associated with these drinking water wells. No contaminants have been detected in water from these wells at levels above drinking water standards. Perchlorate contamination presents an indeterminate past public health hazard because groundwater was not analyzed for perchlorate until 1997. In light of the current low levels of perchlorate in these wells, however, it is unlikely that past exposure to perchlorate presents a public health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Rubio Canyon Land and Water Company drinking water wells	Two drinking water wells are located approximately 1 mile southeast of JPL, in Pasadena. This water source, in combination with imported water, serves approximately 7,350 people.	Perchlorate has been detected at concentrations below California's action level. Organic contaminants were detected below drinking water standards in one well in 1989 but have not been detected in later samples.	Rubio Canyon conducts yearly sampling of its raw water for VOCs, and perchlorate sampling when requested by CDHS. CDHS reviews these sampling data. Because no contaminants have been detected above drinking water standards in raw water samples, CDHS does not require Rubio Canyon to sample its finished water.	No public health hazard is associated with these drinking water wells. No contaminants have been detected in water from these wells at levels above drinking water standards. Perchlorate contamination presents an indeterminate past public health hazard because groundwater was not analyzed for perchlorate until 1997. In light of the current low levels of perchlorate in these wells, however, it is unlikely that past exposure to perchlorate presents a past public health hazard.

TABLE 1 (continued): EVALUATION OF POTENTIAL PUBLIC HEALTH HAZARDS AT JET PROPULSION LABORATORY

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Los Flores Water Company drinking water wells	One drinking water well is located over 1 mile southeast of JPL, in Pasadena. This water source, in combination with imported water, serves approximately 2,800 people. Los Flores imports water throughout the year, and pumps groundwater only during months of peak demand (usually May to November). Los Flores runs an injection/recovery operation to store imported water in its aquifer and pump it back out during times of peak demand.	PCE has recently been detected (4.7 ppb) near the federal MCL in the drinking water well. The source of the PCE has not yet been determined. Perchlorate has been detected below the action level.	Due to the recent detection of PCE, Los Flores plans to perform quarterly sampling of its raw water for VOCs (CDHS has not yet assigned Los Flores an updated sampling schedule.) During well operations, Los Flores will also take monthly or bimonthly perchlorate samples, although CDHS has not required this sampling. Because the samples of raw water have met water quality standards, CDHS has not required Los Flores to sample its finished water. Due to the recent PCE detection, however, Los Flores may voluntarily sample its finished water during the next pumping season.	No public health hazard is associated with these drinking water wells. No contaminants have been detected in water from these wells at levels above drinking water standards. Perchlorate contamination presents an indeterminate past public health hazard because groundwater was not analyzed for perchlorate until 1997. In light of the current low levels of perchlorate in these wells, however, it is unlikely that past exposure to perchlorate presents a public health hazard.

[1] Samples of surface soil (0 to 6 inches deep) generally were not collected at JPL because most of the suspected source areas are buried beneath pavement, buildings, retaining walls, or flower planters. At areas that are exposed at the surface (e.g., the stormwater discharge points), soil sampling began at depths of 1 foot or more. For these areas, ATSDR considered the shallowest samples to be representative of surface soil.

Sources (OU 1): Foster Wheeler, 1997a, 1997b.

Sources (OU 2): Ebasco, 1990a, 1993; Foster Wheeler, 1997c, 1998.

Sources (OU 3): City of Pasadena, 1998; JPL, 1997d; La Cañada, 1998; Lincoln Avenue, 1998; Los Flores, 1998; Raymond Basin, 1997a, 1997b; Rubio Canyon, 1998; Valley Water, 1998.

TABLE 2: EXPOSURE PATHWAYS

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Time of Exposure	Exposed Population	
Completed Exposure Pathways							
Off-site groundwater: Perchlorate contamination	Contaminated soil and groundwater at JPL.	Groundwater	Drinking water pumped from aquifers near JPL.	Ingestion Dermal contact Inhalation	**Past:** Perchlorate in groundwater was not analyzed before 1997. **Present and future:** Perchlorate has been detected at low levels in most of the drinking water wells in the vicinity of JPL. Perchlorate levels exceed California's action level in some wells, which have been either closed down or blended with water from other wells.	Customers of drinking water purveyors located in the vicinity of JPL.	Perchlorate contamination in off-site groundwater presents no apparent present or future public health hazard. The current sampling and blending procedures used by the drinking water purveyors near JPL are expected to prevent any potential present or future public health hazards posed by perchlorate in groundwater. Past exposures to perchlorate contamination present an indeterminate public health hazard because there are no data on perchlorate levels before 1997. Based on the available data, however, it is unlikely that past perchlorate levels in groundwater have posed a public health hazard.

TABLE 2 (continued): EXPOSURE PATHWAYS

Pathway Name	Exposure Pathway Elements: Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Time of Exposure	Exposed Population	Comments
Potential Exposure Pathways							
Off-site groundwater: VOCs contamination	Contaminated soil and groundwater at JPL; other off-site sources may also exist.	Groundwater	Drinking water pumped from aquifers near JPL.	Ingestion Dermal contact Inhalation	**Past, present, and future:** VOCs have been detected in various drinking water wells since the early 1980s.	Customers of water purveyors located in the vicinity of JPL.	VOC contamination in off-site groundwater does not present a past, present, or future public health hazard because water purveyors, under the supervision of CDHS, have regularly monitored drinking water wells and taken steps (e.g., water blending, water treatment, or well closure) to ensure that the water distributed to consumers is safe. Since water purveyors sample their groundwater for VOCs periodically rather than continuously, for short periods of time in the past some purveyors may have provided drinking water containing VOCs above drinking water standards. For all purveyors, however, VOCs have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure.

TABLE 2 (continued): EXPOSURE PATHWAYS

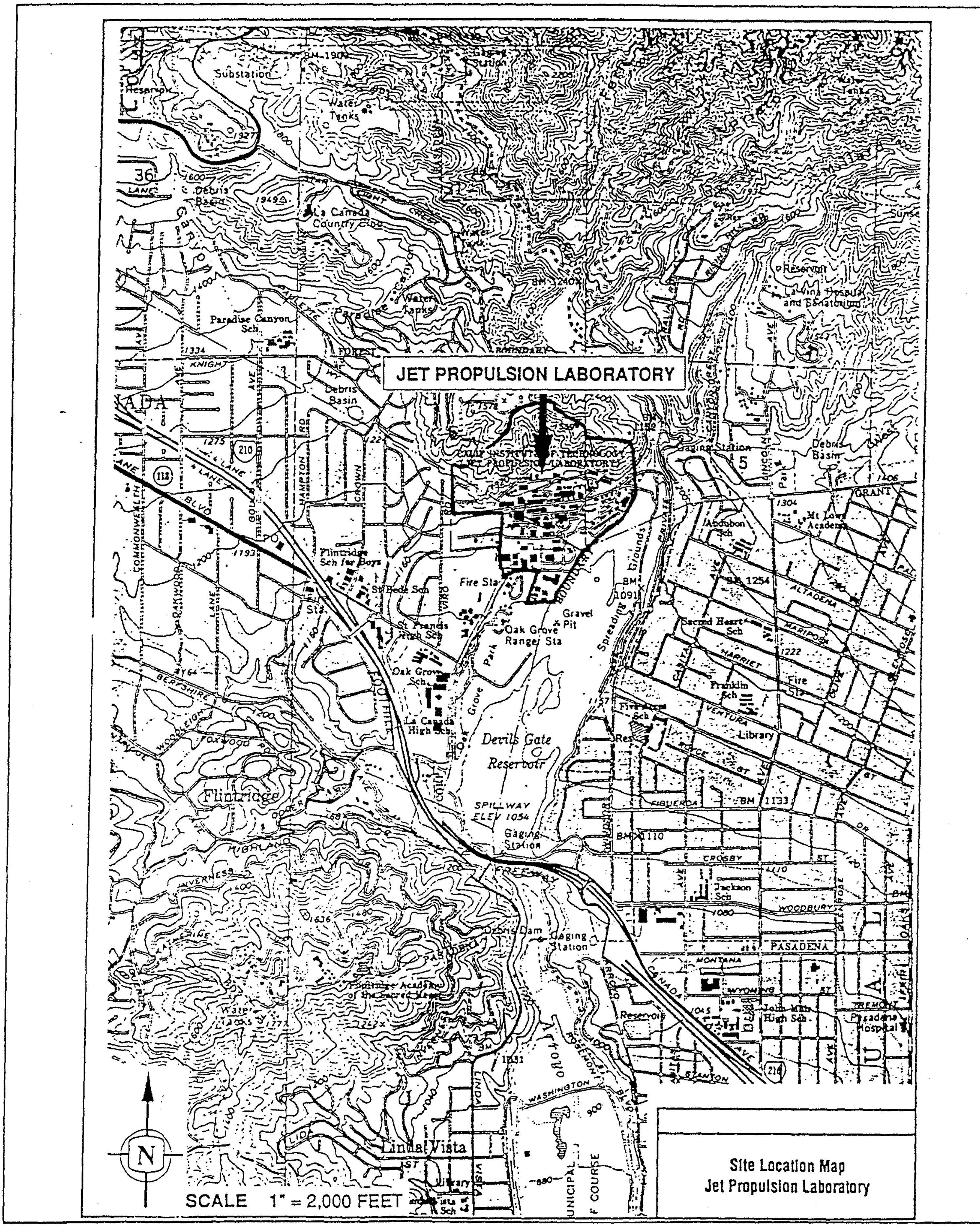
Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Time of Exposure	Exposed Population	
Potential Exposure Pathways (continued)							
On-site soil	Historical disposal of hazardous wastes to on-site seepage pits, waste pits, and stormwater discharge points; miscellaneous spills and chemical releases.	Surface and subsurface soil	Surface soils beneath grass and other vegetation; subsurface soils exposed through construction.	Ingestion Dermal contact	**Past:** Source areas now covered by pavement, buildings, etc. may have been accessible in the past. **Present and future:** Several seepage pits are located in areas covered with grass or other vegetation. The depths of these seepage pits beneath the surface are not known in all cases, but it is unlikely that any of them are located at the surface.	JPL employees and construction workers	Contaminated soils at JPL do not present a public health hazard because these soils do not contain contaminants at levels that pose a public health hazard and/or they are inaccessible to JPL workers. Although workers could be exposed to currently inaccessible subsurface soils during future excavation, demolition, or construction work, ATSDR assumes that these workers will wear proper protective equipment in accordance with OSHA regulations.

TABLE 2 (continued): EXPOSURE PATHWAYS

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	**Environmental Medium**	**Point of Exposure**	**Route of Exposure**	**Time of Exposure**	**Exposed Population**	
Potential Exposure Pathways (continued)							
On-site VOC vapors	Historical disposal of VOCs to on-site seepage pits.	Indoor air	Basements/ lower levels of buildings near contaminated soil.	Inhalation	**Past:** VOC vapors were detected at relatively shallow depths in soil-vapor probes 31 and 33, located near Building 107. There are no data on past indoor air quality in this building. **Present and future:** Air quality samples taken in May 1998 showed that there were no VOC vapors in Building 107.	JPL employees in affected buildings.	No public health hazard is associated with indoor VOC vapors because recent sampling indicated that VOC vapors are not present in Building 107.
Off-site soil	Historical disposal of hazardous wastes to waste pits and stormwater discharge points.	Surface and subsurface soil	Waste pits (WP-1, WP-2, and WP-4) that extend over the property boundary into the Arroyo Seco; off-site stormwater discharge points (DP-1 and DP-3) in the Arroyo Seco.	Ingestion Dermal contact	**Past, present, and future:** Any exposure to contaminated soil through recreational use at these sites is likely to be infrequent and of short duration.	Hikers, horseback riders, and others who use the Arroyo Seco for recreation.	No public health hazard is associated with off-site soil because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access these areas, contamination was not detected at levels that pose a public health hazard.

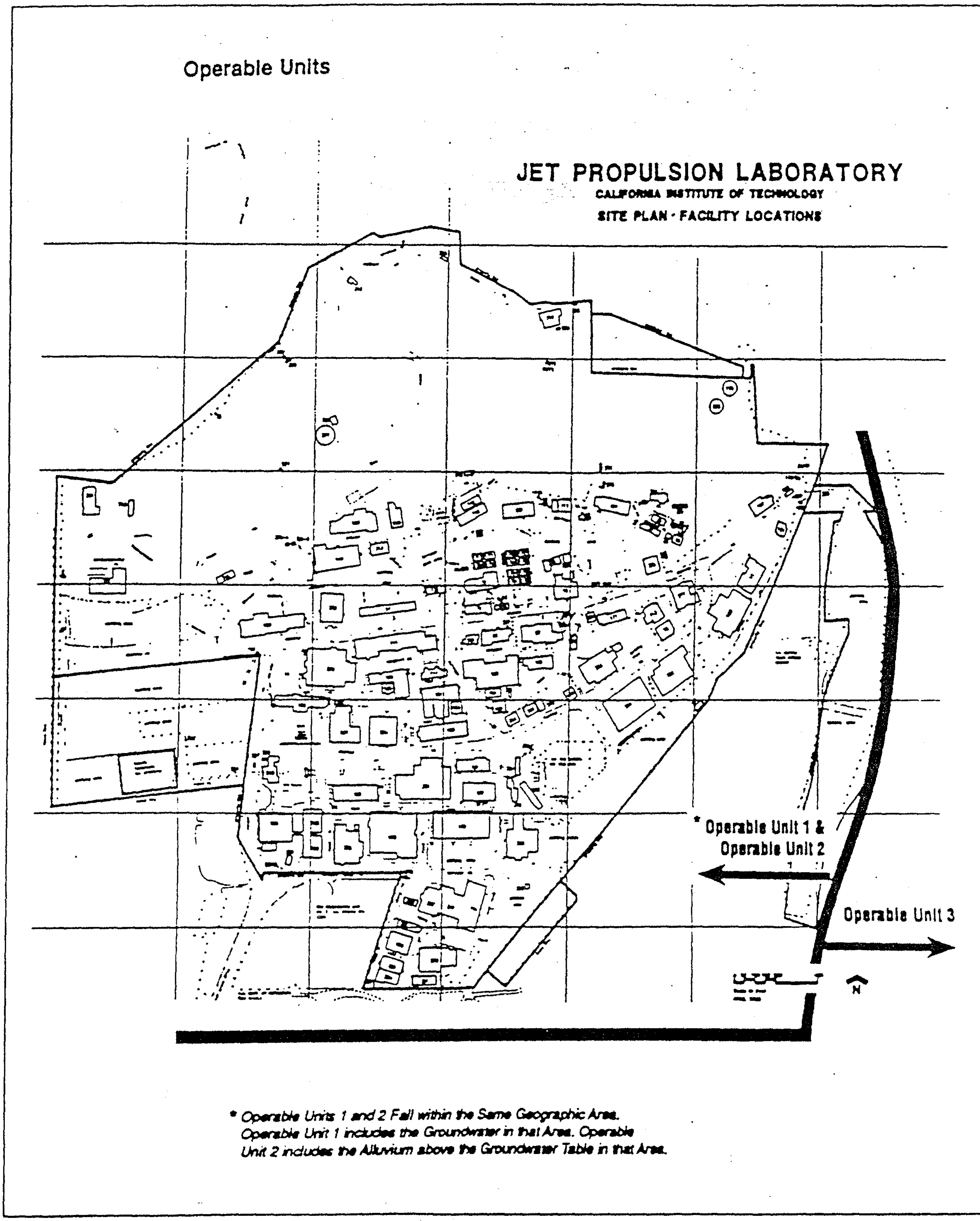
FIGURES

Figure 1



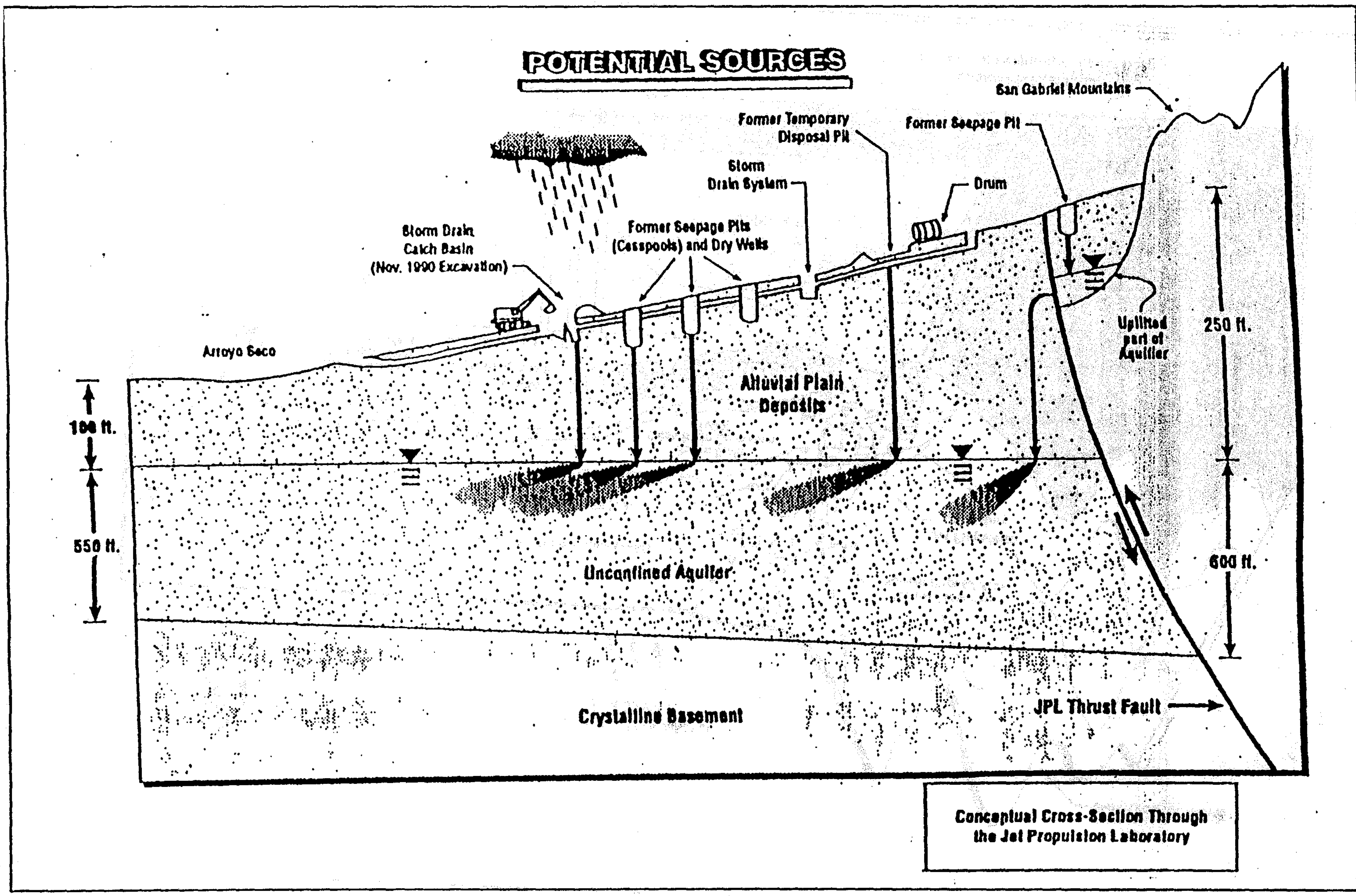
Source: Ebasco, 1993.

Figure 2



Source: JPL, 1994c

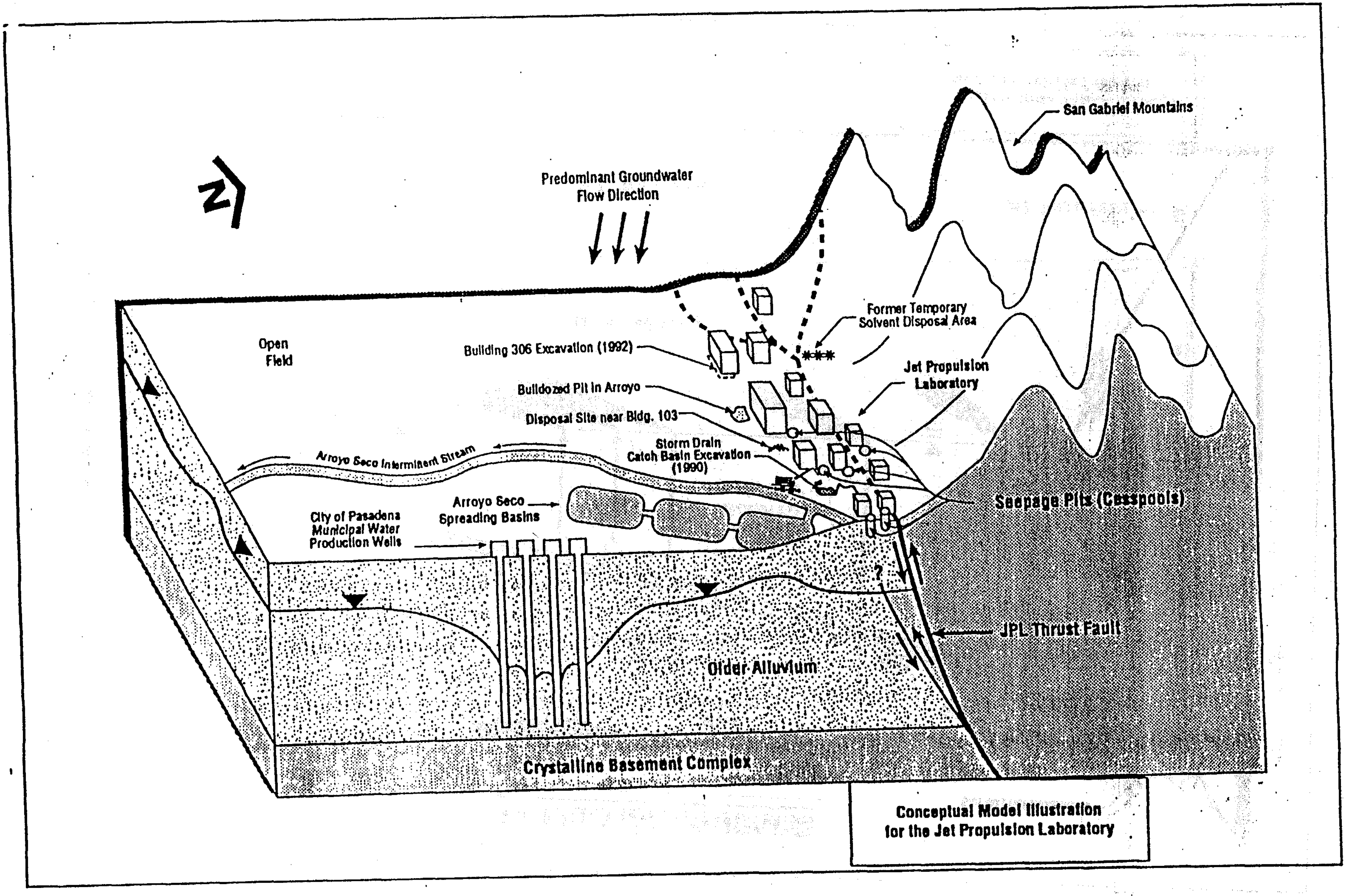
Figure 3



Conceptual Cross-Section Through the Jet Propulsion Laboratory

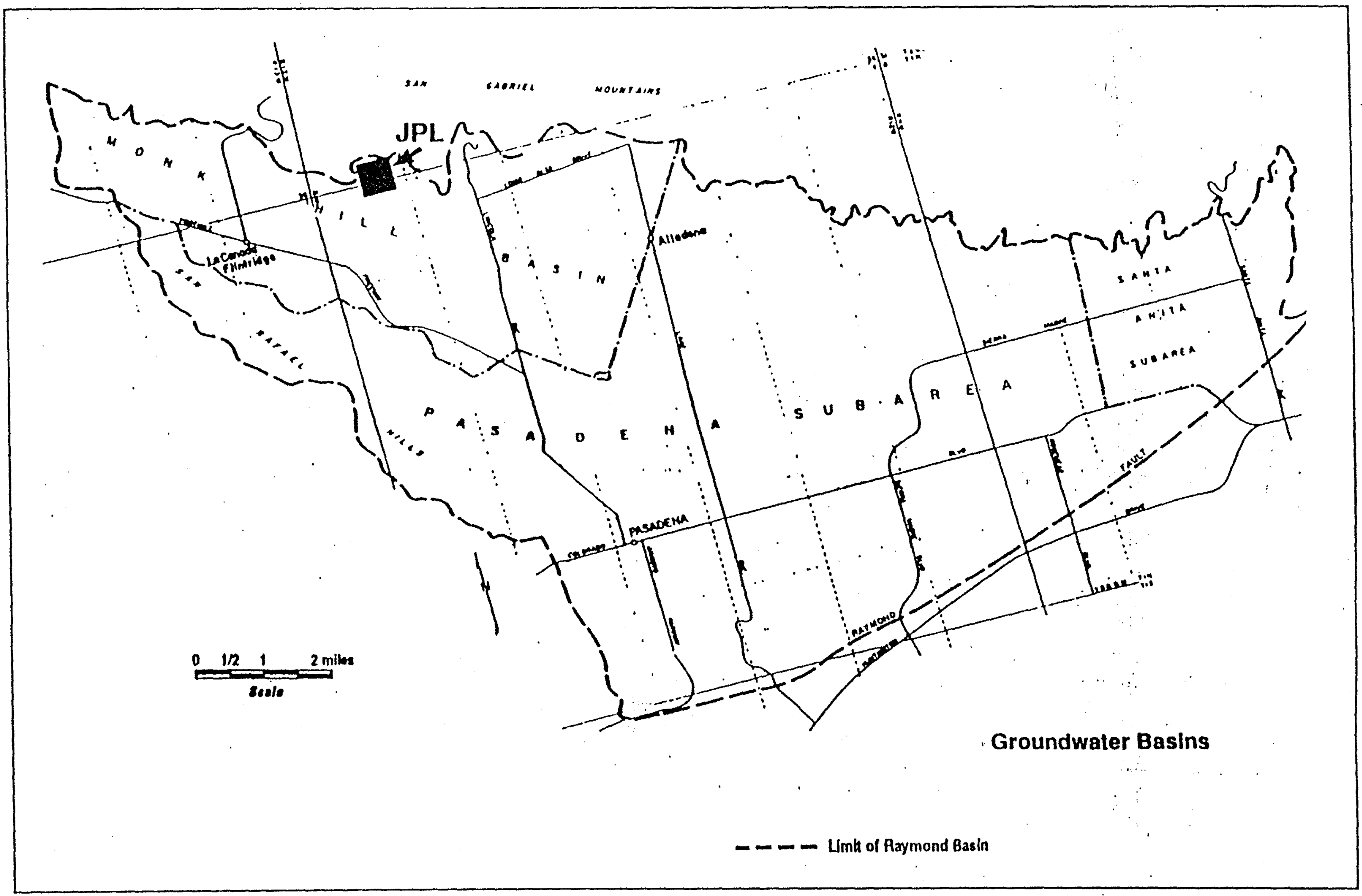
Source: Ebasco, 1993.

Figure 4



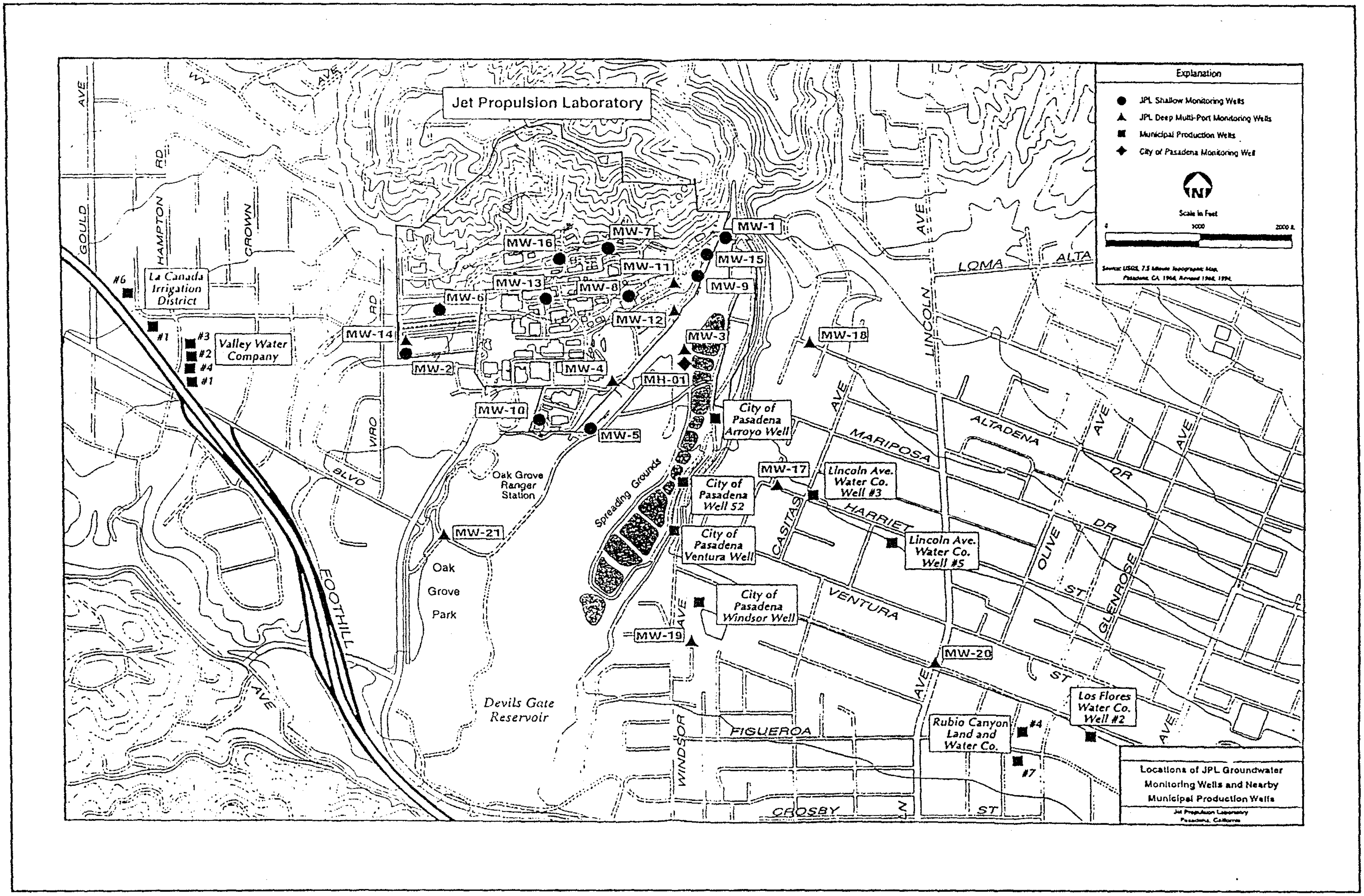
Source: Ebasco, 1993.

Figure 5



Source: JPL, 1994c.

Figure 6



Source: Foster Wheeler, 1997b.

Figure 7

ATSDR's Exposure Evaluation Process

REMEMBER: For a public health threat to exist, the following three conditions must all be met:

- People must come into contact with areas that have potential contamination
- Contaminants must exist in the environment
- The amount of contamination must be sufficient to affect people's health

Are People Exposed To Areas With Potentially Contaminated Media?

For exposure to occur, contaminants must be in locations where people can contact them.

People may contact contaminants by any of the following three exposure routes:

Inhalation
Ingestion
Dermal absorption

Are the Environmental Media Contaminated?

ATSDR considers:

Soil
Ground water
Surface water and sediment
Air
Food sources

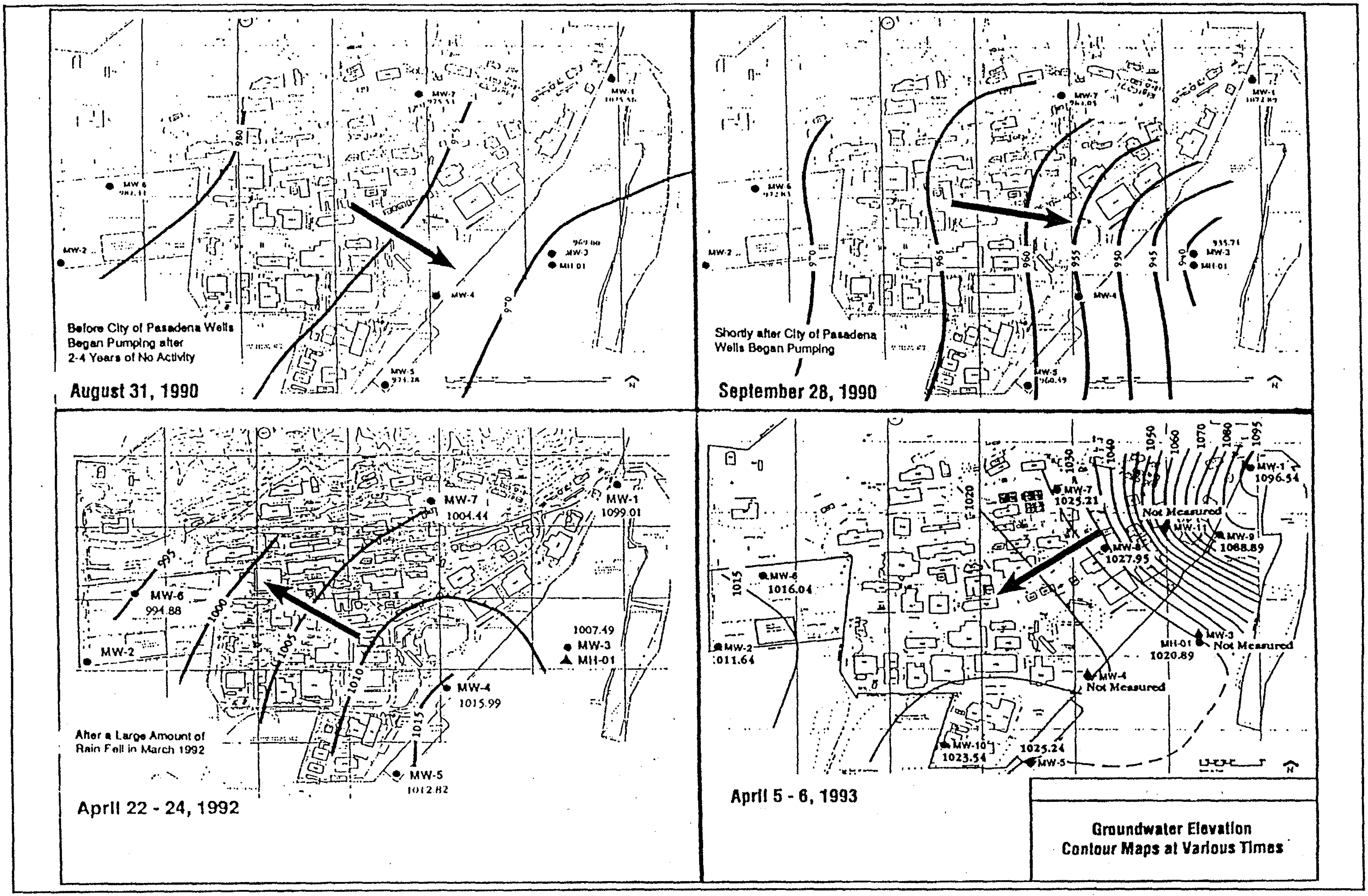
For Each Completed Exposure Pathway, Will the Contamination Affect Public Health?

ATSDR will evaluate existing data on contaminant concentration and exposure duration and frequency.

ATSDR will also consider individual characteristics (such as age, gender, and lifestyle) of the exposed population that may influence the public health effects of contamination.

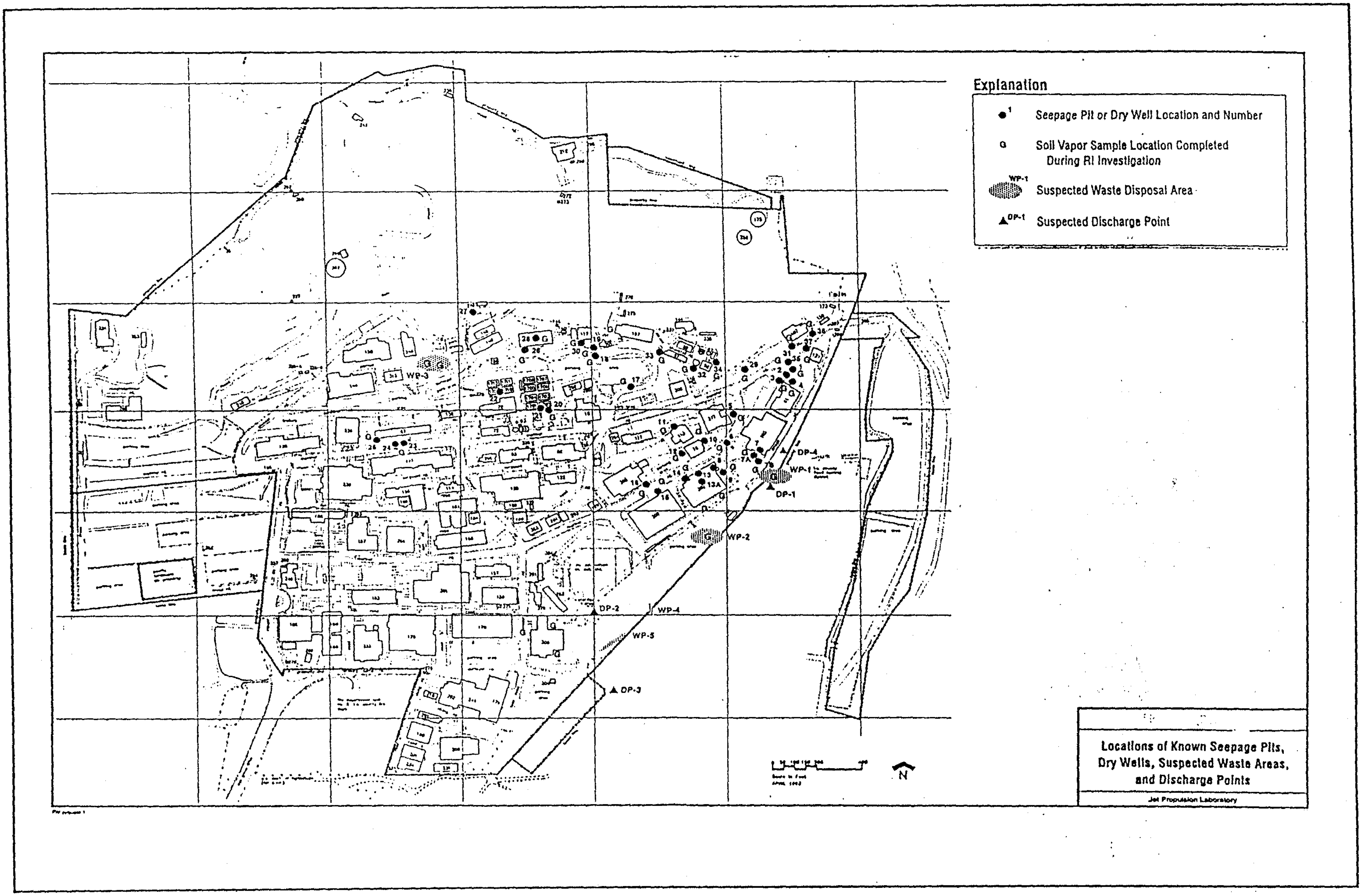
Source: Foster Wheeler, 1997b.

Figure 8



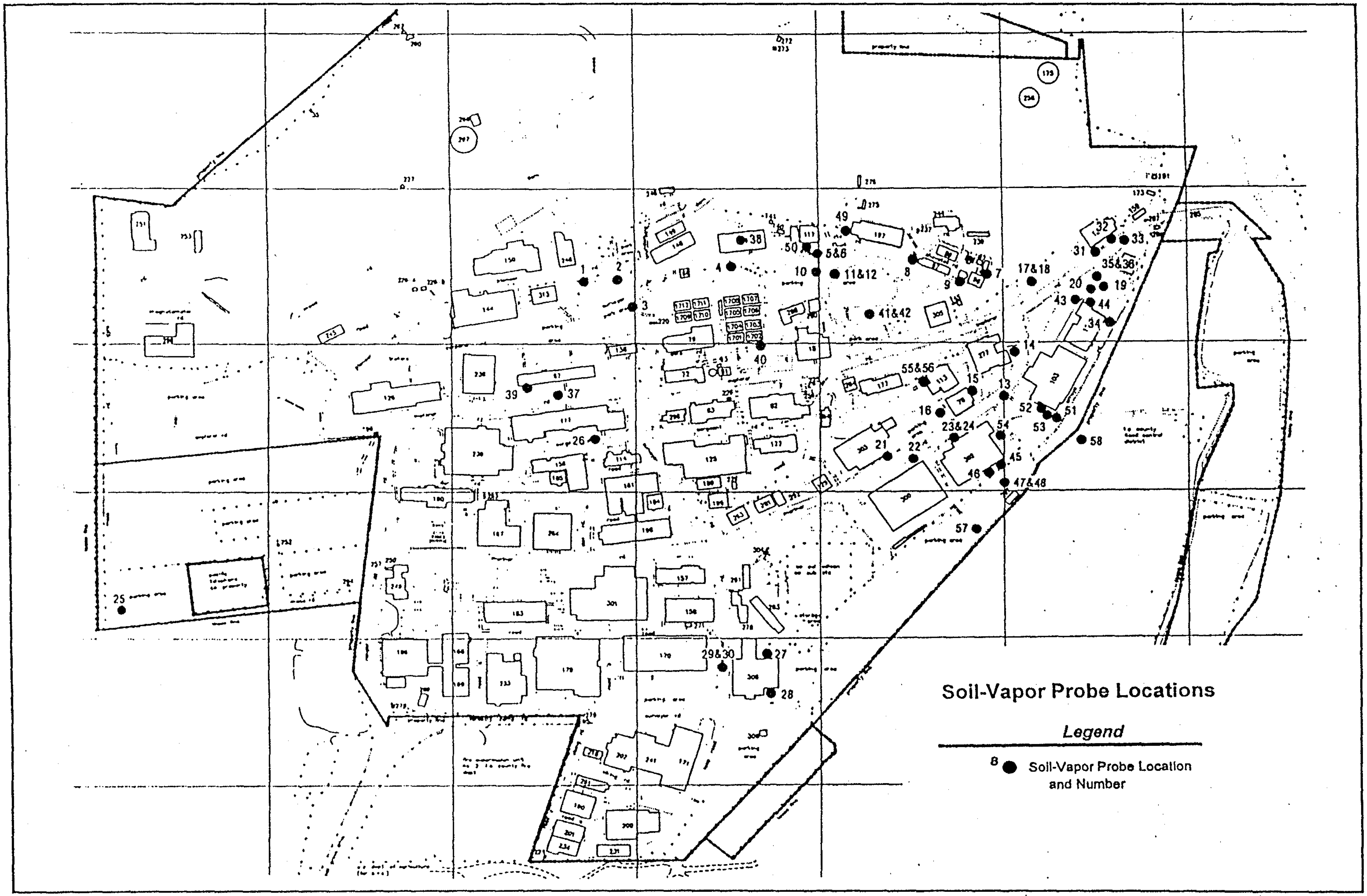
Source: Ebasco, 1993.

Figure 9



Source: Foster Wheeler, 1997c.

Figure 10



Source: Foster Wheeler, 1997c.

APPENDICES

APPENDIX A: Glossary

Acute

Occurring over a short time, usually a few minutes or hours. An *acute* exposure can result in short-term or long-term health effects. An *acute* effect happens a short time (up to 1 year) after exposure.

Ambient

Surrounding. For example, *ambient* air is usually outdoor air (as opposed to indoor air).

Analyte

A chemical component of a sample to be determined or measured. For example, if the *analyte* is mercury, the laboratory test will determine the amount of mercury in the sample.

Background Level

A typical or average level of a chemical in the environment. *Background* often refers to naturally occurring or uncontaminated levels.

Carcinogen

Any substance that may produce cancer.

CERCLA

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund. This is the legislation that created ATSDR.

Chronic

Occurring over a long period of time (more than 1 year).

Comparison Values

Estimated contaminant concentrations in specific media that are not likely to cause adverse health effects, given a standard daily ingestion rate and standard body weight. The *comparison values* are calculated from the scientific literature available on exposure and health effects.

Concentration

The amount of one substance dissolved or contained in a given amount of another. For example, sea water contains a higher concentration of salt than fresh water.

Contaminant

Any substance or material that enters a system (the environment, human body, food, etc.) where it is not normally found.

Dermal

Referring to the skin. *Dermal* absorption means absorption through the skin.

Dose

The amount of substance to which a person is exposed. *Dose* often takes body weight into account.

Environmental contamination

The presence of hazardous substances in the environment. From the public health perspective, *environmental contamination* is addressed when it potentially affects the health and quality of life of people living and working near the contamination.

Exposure

Contact with a chemical by swallowing, by breathing, or by direct contact (such as through the skin or eyes). *Exposure* may be short term (acute) or long term (chronic).

Exposure Investigation

The collection and analysis of site-specific information to determine if human populations have been exposed to hazardous substances. The site-specific information may include environmental sampling, exposure-dose reconstruction, biologic or biomedical testing, and evaluation of medical information. The information from an *exposure investigation* is included in public health assessments, health consultations, and public health advisories.

Hazard

A source of risk that does not necessarily imply potential for occurrence. A hazard produces risk only if an exposure pathway exists, and if exposures create the possibility of adverse consequences.

Health Investigation

Any investigation of a defined population, using epidemiologic methods, which would assist in determining exposures or possible public health impact by defining health problems requiring further investigation through epidemiologic studies, environmental monitoring or sampling, and surveillance.

Health Consultation

A response to a specific question or request for information pertaining to a hazardous substance or facility (which includes waste sites). It often contains a time-critical element that necessitates a rapid response; therefore, it is a more limited response than an assessment.

Health Outcome Data

A major source of data for public health assessments. The identification, review, and evaluation of health outcome parameters are interactive processes involving the health assessors, data source generators, and the local community. *Health outcome data* are community specific and may be derived from databases at the local, state, and national levels, as well as from data collected by private health care organizations and professional institutions and associations. Databases to be considered include morbidity and mortality data, birth statistics, medical records, tumor and disease registries, surveillance data, and previously conducted health studies.

Ingestion

Swallowing (such as eating or drinking). Chemicals can get in or on food, drink, utensils, cigarettes, or hands where they can be ingested. After *ingestion*, chemicals can be absorbed into the blood and distributed throughout the body.

Inhalation

Breathing. Exposure may occur from inhaling contaminants because they can be deposited in the lungs, taken into the blood, or both.

Media

Soil, water, air, plants, animals, or any other parts of the environment that can contain contaminants.

Minimal Risk Level (MRL)

An *MRL* is defined as an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (noncancer) over a specified duration of exposure. *MRLs* are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration via a given route of exposure. *MRLs* are based on noncancer health effects only. *MRLs* can be derived for acute, intermediate, and chronic duration exposures by the inhalation and oral routes.

National Priorities List (NPL)

The Environmental Protection Agency's (EPA) listing of sites that have undergone preliminary assessment and site inspection to determine which locations pose immediate threat to persons living or working near the release. These sites are most in need of cleanup.

No Apparent Public Health Hazard

Sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.

No Public Health Hazard

Sites for which data indicate no current or past exposure or no potential for exposure and therefore no health hazard.

Plume

An area of chemicals in a particular medium, such as air or groundwater, moving away from its source in a long band or column. A *plume* can be a column of smoke from a chimney or chemicals moving with groundwater.

Potential/Indeterminate Public Health Hazard

Sites for which no conclusions about public health hazard can be made because data are lacking.

Potentially Exposed

The condition where valid information, usually analytical environmental data, indicates the presence of contaminant(s) of a public health concern in one or more environmental media contacting humans (i.e., air, drinking water, soil, food chain, surface water), and there is evidence that some of those persons have an identified route(s) of exposure (i.e., drinking contaminated water, breathing contaminated air, having contact with contaminated soil, or eating contaminated food).

Public Availability Session

An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public Comment

An opportunity for the general public to comment on Agency findings or proposed activities. The public health assessment process, for example, includes the opportunity for public comment as the last step in the draft phase. The purposes of this activity are to 1) provide the public, particularly the community associated with a site, the opportunity to comment on the public health findings contained in the public health assessment, 2) evaluate whether the community health concerns have been adequately addressed, and 3) provide ATSDR with additional information.

Public Health Action

Designed to prevent exposures and/or to mitigate or prevent adverse health effects in populations living near hazardous waste sites or releases. Public health actions can be identified from information developed in public health advisories, public health assessments, and health consultations. These actions include recommending the dissociation (separation) of individuals from exposures (for example, by providing an alternative water supply), conducting biologic indicators of exposure studies to assess exposure, and providing health education for health care providers and community members.

Public Health Advisory

A statement by ATSDR containing a finding that a release of hazardous substances poses a significant risk to human health and recommending measures to be taken to reduce exposure and eliminate or substantially mitigate the significant risk to human health.

Public Health Assessment

The evaluation of data and information on the release of hazardous substances into the environment in order to assess any current or future impact on public health, develop health advisories or other recommendations, and identify studies or actions needed to evaluate and mitigate or prevent human health effects; also, the document resulting from that evaluation.

Public Health Hazard

Sites that pose a public health hazard as the result of long-term exposures to hazardous substances.

Risk

In risk assessment, the probability that something will cause injury, combined with the potential severity of that injury.

Risk Communication

Activities to ensure that messages and strategies designed to prevent exposure, adverse human health effects, and diminished quality of life are effectively communicated to the public. As part of a broader prevention strategy, risk communication supports education efforts by promoting public awareness, increasing knowledge, and motivating individuals to take action to reduce their exposure to hazardous substances.

Route of Exposure

The way in which a person may contact a chemical substance. For example, drinking (ingestion) and bathing (skin contact) are two different *routes of exposure* to contaminants that may be found in water.

Significant Health Risk

Circumstances where people are being or could be exposed to hazardous substances at levels that pose an urgent public health hazard or a public health hazard; public health advisories are generally issued when urgent public health hazards have been identified.

Superfund

Another name for the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), which created ATSDR.

Superfund Amendments and Reauthorization Act (SARA)

The 1986 legislation that broadened ATSDR's responsibilities in the areas of public health assessments, establishment and maintenance of toxicologic databases, information dissemination, and medical education.

Toxicological Profile

A document about a specific substance in which ATSDR scientists interpret all known information on the substance and specify the levels at which people may be harmed if exposed. The *toxicological profile* also identifies significant gaps in knowledge on the substance, and serves to initiate further research, where needed.

Volatile organic compounds (VOCs)

Substances containing carbon and different proportions of other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur, or nitrogen; these substances easily become vapors or gases. A significant number of the *VOCs* are commonly used as solvents (paint thinners, lacquer thinner, degreasers, and dry cleaning fluids).

APPENDIX B: Perchlorate in Groundwater at Jet Propulsion Laboratory

Background

The perchlorate ion (ClO_4^-) is often used by chemists to promote crystallization of compounds. Perchlorate is soluble in water and is a strong oxidant Ammonium perchlorate (NH_4ClO_4), in particular, is used in the manufacture of solid rocket fuel, fireworks, and explosive devices.

Although perchlorate has been known as an environmental contaminant at some hazardous waste sites, no standardized methods exist for detecting perchlorate in water, and, until recently, perchlorate could not be detected at concentrations below 400 ppb. In 1997, Aerojet Corporation—a company responsible for a Superfund site in southern California where perchlorate has been a contaminant of concern—developed a new analytical method to detect perchlorate concentrations as low as 4 ppb. CDHS subsequently began urging California water purveyors and responsible parties at hazardous waste sites to analyze groundwater for perchlorate using the new test method. Since sampling began in the summer of 1997, perchlorate has been detected at low levels in wells throughout southern California, and at higher levels in some areas. As a result, regulatory agencies, water purveyors, and the public are becoming more aware of perchlorate as a potential contaminant in drinking water and are especially interested in the potential health effects of this contaminant.

Health Effects

In 1992 and again in 1995, EPA evaluated the body of toxicological information on perchlorate and determined that, although there is considerable information about the health effects from short-term exposure to perchlorate, there is not enough information about the effects from long-term exposure (CDHS, 1997). At high levels, perchlorate can interfere with production of thyroid hormones and lead to below-normal levels of thyroid hormones in the blood. This condition, called hypothyroidism, can cause the body to increase its production of thyroid stimulating hormone (TSH). Increased levels of TSH may cause enlargement of the thyroid and a person to feel sluggish, depressed, cold, or tired. Because perchlorate can reduce the body's level of thyroid hormone, in the past doctors used high doses of potassium perchlorate ($KClO_4$) as a drug treatment for people with hyperthyroidism, a condition in which the thyroid produces an above-normal amount of hormones (this condition is often caused by Grave's Disease). Perchlorate treatments were discontinued when some patients developed blood or immune system disorders. It is unknown if perchlorate caused these problems, however (CDHS, 1997). As the interest in perchlorate contamination has grown, EPA and other researchers have begun new studies on the toxicological effects of perchlorate. ATSDR will analyze all new data on perchlorate as they become available, and will use any and all new information to further evaluate the perchlorate contamination at JPL.

Safe Drinking Water Levels

Based on the existing toxicological studies of perchlorate, EPA derived a provisional reference dose (RfD) for perchlorate. An RfD is a dose of chemical to which a person could be exposed over a long period of time without an increased risk of adverse, non-cancer health effects. Using the available toxicological information, EPA estimated that a perchlorate dose of 0.14 mg/kg/day (i.e., a mg of perchlorate absorbed per kilogram of a person's body weight per day) would not be expected to adversely affect a person's thyroid. By applying a safety margin of 300 to 1,000 to this value to account for any uncertainties in the toxicological data, EPA derived an RfD of 1 to 5 x 10^{-4} mg/kg/day. CDHS used the upper limit of this range (0.0005 mg/kg/day) to determine a provisional drinking water standard (called an "action level") of 18 ppb for California. Because of the 300-fold margin of safety, this action level would translate to a perchlorate dose that is 300 times less than the lowest dose of perchlorate at which no adverse health affects have been observed. For example, although the action level is 18 ppb, a person could drink 8 cups (approximately 2 liters) of water contaminated with 540 ppb perchlorate and still be ingesting 10 times less perchlorate than the lowest amount at which no health effect has been observed in toxicological studies.

Monitoring Drinking Water for Perchlorate

Since CDHS initiated sampling in 1997, perchlorate has been detected in numerous monitoring and drinking water wells in the Monk Hill Sub-basin and elsewhere in the Raymond Basin (groundwater basins are shown in Figure 5). CDHS schedules sampling for the various water purveyors in the area to ensure that perchlorate levels are adequately monitored. CDHS regularly reviews the sampling data from all water purveyors, and adjusts the required sampling schedules as contaminant concentrations in the wells change. If perchlorate concentrations rise above the action level in drinking water wells, CDHS requires the water purveyor to shut down the contaminated well or take other steps (e.g., blending the groundwater with imported water or water from other wells) to ensure that the finished drinking water distributed to consumers meets the action level. If a water purveyor is unable to take these steps, it is required to inform its customers about the contaminated drinking water. In addition to the samples mandated by CDHS, many water purveyors perform more frequent sampling to ensure their compliance with water quality standards. Current sampling schedules of the water purveyors closest to JPL are listed in Table 1.

Perchlorate at JPL

In the summer of 1997, sampling showed the presence of perchlorate in JPL monitoring wells and in Pasadena municipal wells located east/southeast of JPL. Perchlorate concentrations above the CDHS action level forced the closure of the Pasadena drinking water well located closest to JPL (the Arroyo Well—see Figure 6). Perchlorate levels have recently risen above the action level in the next Pasadena well downgradient to JPL, Well No. 52. By blending the water from this well with water from the remaining drinking water wells, Pasadena has been able to avoid shutting down Well No. 52 while still providing finished water that is below the action level for perchlorate (City of Pasadena, 1998). In 1997, JPL sampled tap water from several locations at the facility and did not detect perchlorate above the action level (JPL, 1997c). The current sampling and blending procedures used at the drinking water wells near JPL are expected to prevent any potential present or future public health hazards posed by perchlorate in groundwater.

Perchlorate in groundwater was not analyzed before 1997, so it is unknown what the perchlorate levels in the Pasadena drinking water wells or other nearby wells were in the past. The rise in perchlorate levels observed during 1997 in the Pasadena wells may indicate that perchlorate levels were lower in these wells in the past. Although the Arroyo Well had perchlorate levels above the action level when perchlorate analysis began, the other three wells did not exceed the action level, so the blended water from these four wells probably did not exceed the action level. Even if finished water from these wells did exceed the action level in the past, this action level is very conservative. In fact, the maximum perchlorate concentration detected at JPL to date (615 ppb, in monitoring well MW-16), if present in drinking water, would still translate to a dose of perchlorate that is about eight times less than the lowest dose at which no health effect has been observed in toxicological studies. Based on the available data from JPL, it is unlikely that past perchlorate levels in groundwater have posed a public health hazard. Because there is no information on past perchlorate levels, however, ATSDR considers past exposures to perchlorate in off-site groundwater at JPL to be an indeterminate public health hazard.

Cleaning Up Perchlorate

The only known method of removing low levels of perchlorate from water is a reverse osmosis membrane technique that is very expensive (Bookman-Edmonston, 1997) and has not been implemented on a large scale for drinking water. EPA, the Department of Defense, responsible parties at hazardous waste sites, environmental technology companies, and university researchers are studying potential perchlorate cleanup technologies. JPL and its environmental contractors are currently looking at a number of possible cleanup strategies, including ion-exchange resins and hydrogenation. After it develops a series of test systems for the most promising technologies, JPL hopes to arrive at a feasible cleanup system for use at JPL (JPL, 1998). The Raymond Basin Management Board has organized a Perchlorate Task Force—made up of water purveyors, state and federal regulators, and other interested parties—to look at ways to prevent, minimize, and clean up perchlorate contamination in the groundwater of the Raymond Basin. ATSDR will evaluate any developments in perchlorate treatment to assess their potential effect on environmental conditions and public health at JPL.

Conclusions

Regular sampling for perchlorate, together with water blending or well closures (when necessary) now ensure that all water distributed to consumers meets California's action level for perchlorate. ATSDR believes these actions will continue to eliminate any potential public health hazard posed by exposure to perchlorate in groundwater near JPL. The presence of perchlorate contamination in groundwater is not without consequences, however. Because there is currently no practical way to remove perchlorate from water, if perchlorate levels continue to rise in the groundwater near JPL, water purveyors may need to close down more of their drinking water wells. If these water purveyors are forced to replace their groundwater with much more expensive imported water, the increased cost could have a large economic impact on the communities that depend on these water purveyors to supply their drinking water. In addition, the availability of imported water in California can vary dramatically from year to year, depending on a host of conditions throughout the southwestern United States including rainfall, water demand, and ecological conditions. The conservation, preservation, and remediation of groundwater supplies is therefore vitally important to the people of southern California.

APPENDIX C: Population and Housing Data; Census Tract Map

POPULATION DATA TABLE
NASA Jet Propulsion Laboratory, Los Angeles County

	La Canada-Flintridge[1]	La Canada-Flintridge[2]	Altadena[3]	Altadena[4]
Total persons	5,294	4,245	4,200	6,006
Total area, square miles	2.92	1.00	0.50	0.7
Persons per square mile	1,815	4,250	8,329	8,528
% Male	49.7	48.6	48.8	49.9
% Female	50.3	51.4	51.2	50.1
% White	83.1	85.3	19.5	18.5
% Black	0.2	0.0	67.3	59.8
% American Indian, Eskimo, or Aleut	0.2	0.0	0.3	0.5
% Asian or Pacific Islander	15.4	13.5	2.9	4.2
% Other races	1.2	1.2	10.0	17.0
% Hispanic origin	3.8	4.8	16.0	27.4
% Under age 10	12.7	14.3	17.3	19.2
% Age 65 and older	12.1	13.8	10.1	8.7

Source: Census of Population and Housing, 1990: Summary Tape File 1A (California) [machine-readable data files]. Prepared by the Bureau of the Census. Washington, DC: The Bureau [producer and distributor], 1991.

[1] Tract 4605.01 (see census tract map)
[2] Tract 4505.02 (see census tract map)
[3] Tract 4603.02 (see census tract map)
[4] Tract 4610.00 (see census tract map)

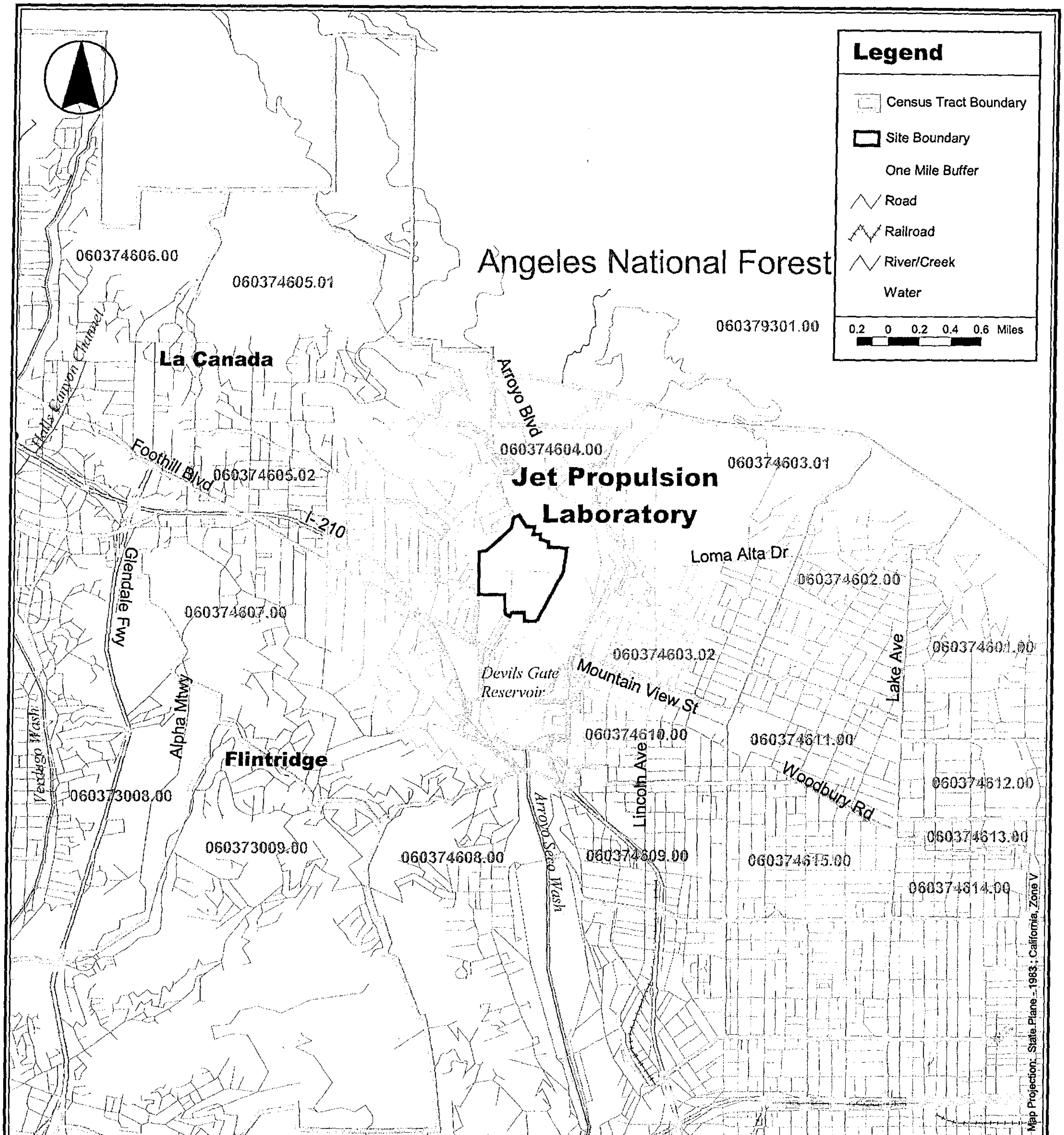
HOUSING DATA TABLE
NASA Jet Propulsion Laboratory, Los Angeles County

	La Canada-Flintridge[1]	La Canada-Flintridge[2]	Altadena[3]	Altadena[4]
Households*	1,331	1,785	1,469	1,713
Persons per household	3.11	2.97	2.89	3.44
% Households owner-occupied	75.5	94.5	90.5	67.4
% Households renter-occupied	24.5	5.5	9.5	32.6
% Households mobile homes	0.2	0.0	0.0	0.1
% Persons in group quarters	1.5	0.0	0.0	1.8
Median value, owner-occupied households, $	167,800	500,001	467,900	157,700
Median rent paid, renter-occupied households, $	572	1,001	969	549

Source: Census of Population and Housing, 1990: Summary Tape File 1A (California) [machine-readable data files]. Prepared by the Bureau of the Census. Washington, DC: The Bureau [producer and distributor], 1991.

* A household is an occupied housing unit, but does not include group quarters such as military barracks, prisons, and college dormitories.

[1] Tract 4605.01 (see census tract map)
[2] Tract 4505.02 (see census tract map)
[3] Tract 4603.02 (see census tract map)
[4] Tract 4610.00 (see census tract map)



U.S. Census Tracts
Jet Propulsion Laboratory

Pasadena, California

CERCLIS No. CA9800013030

VICINITY MAP

Base Map Source: 1995 TIGER/Line Files

Site Location

Los Angeles County, California

ATSDR GIS Spatial Analysis Activity

ALD 06241998

APPENDIX D: ATSDR's Comparison Values

The conclusion that a contaminant exceeds the comparison value does not mean that it will cause adverse health effects. Comparison values represent media-specific contaminant concentrations that are used to select contaminants for further evaluation to determine the possibility of adverse public health effects.

Cancer Risk Evaluation Guides (CREGs)

CREGs are estimated contaminant concentrations that would be expected to cause no more than once excess cancer in a million (10^{-6}) persons exposed over a lifetime. ATSDR's CREGs are calculated from EPA's cancer potency factors.

Environmental Media Evaluation Guides (EMEGs)

EMEGs are based on ATSDR minimal risk levels (MRLs) and factors in body weight and ingestion rates. An EMEG is an estimate of daily human exposure to a chemical (in mg/kg/day) that is likely to be without noncarcinogenic health effects over a specified duration of exposure.

Maximum Contaminant Level (MCL)

The MCL is the drinking water standard established by EPA. It is the maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet. MCLs are considered protective of public health over a lifetime (70 years) for people consuming 2 liters of water per day.

Reference Media Evaluation Guides (RMEGs)

ATSDR derives RMEGs from EPA's oral reference doses. The RMEG represents the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects.